LABORATORY HANDBOOK OF TOXIC AGENTS

C. H. GRAY
Editor-in-Chief

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THE ROYAL INSTITUTE OF CHEMISTRY

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LONDON: THE ROYAL INSTITUTE OF CHEMISTRY
30 RUSSELL SQUARE, W.C.1.

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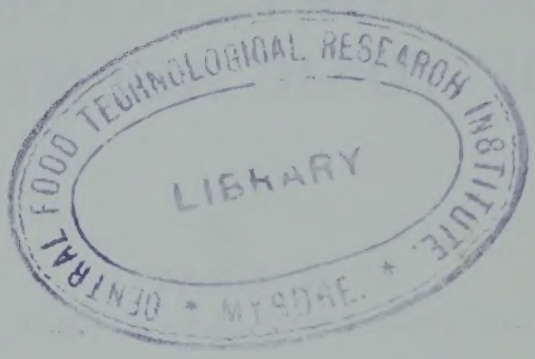

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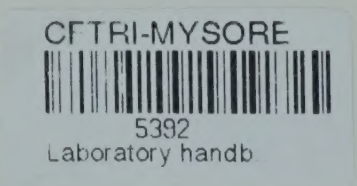
First published 1960

Reprinted January, 1961



Printed in Great Britain at the Works of
W. HEFFER & SONS LTD., CAMBRIDGE, ENGLAND

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PREFACE

In 1958, the Publications Committee of the Royal Institute of Chemistry appointed a Sub-Committee, consisting of Dr F. A. Robinson, Dr F. W. Gibbs and myself, to consider the need for a Handbook on Toxicology that would give general information about the toxic hazards associated with the use of familiar chemicals and their acute, chronic and toxic effects. The present volume is the result of the deliberations of this Committee, the members of which record their gratitude to Dr Frank Hartley, Mr E. J. Vaughan and Dr Ethel Browning in finding appropriate authors for the various sections.

In planning a book which is intended to be available on the work bench, ready for use in an emergency at any time, the selection of subject matter has necessarily been a major problem. As the various contributors have stressed, the materials considered are restricted to those in general use. Those specific to particular industries, as well as less common reagents used in research or in small amounts, have been omitted, as well as certain common solvents, the main laboratory hazards of which arise from their inflammability. It is emphasized throughout that a material which is not included is not necessarily harmless. If any attempt had been made to make the account comprehensive, there would have resulted an unnecessary rival to the encyclopaedic standard works, such as that by Sax. As the main part of the book is arranged alphabetically and a glossary of less common terms is given, it did not seem necessary to provide a separate index for the remainder, which is intended to be read at leisure; the headlines and subject divisions are thought to be adequate for this purpose.

The authors of the section on Poisonous and Corrosive Gases, Reagents and Solvents are grateful to Mr L. T. le G. Burley, Director of The British Drug Houses Ltd, for permission to draw on accumulated records in the B.D.H. Laboratory Chemicals Division. They also acknowledge their indebtedness and express their thanks to Dr A. J. Amor, Dr A. Lloyd Potter, Dr L. J. Burrage and Imperial Chemical Industries Ltd, General Chemicals Division, and Dr B. W. Rhodes of the B.D.H. Laboratory Chemicals Division, for their valuable advice on compiling the material and for reading the manuscript; to Imperial Chemical Industries Ltd, for supplying much useful information about a wide range of their products; to Messrs W. J. Bush & Co. Ltd, Victor Blagden & Co. Ltd, Robinson Brothers Ltd, Ward, Blenkinsop & Co. Ltd and Whiffen & Sons Ltd for information about individual products; and to many colleagues who have contributed from their experience useful information and advice on the properties and hazards of individual compounds. They have drawn greatly upon the published work of many authorities on industrial toxicology, in particular the

Chemical Safety Data Sheets issued by the Manufacturing Chemists' Association Inc.; *Dangerous Properties of Industrial Materials* by N. Irving Sax; *Gassing Casualties* by the Association of British Chemical Manufacturers; *Industrial Hygiene and Toxicology*, ed. by Frank A. Patty; *Industrial Toxicology* by L. S. Fairhall; *Marking Containers* by the Association of British Chemical Manufacturers; *Poisoning by Drugs and Chemicals* by P. Cooper; *Poisons* by Brookes and Jacobs; and *Toxicity of Industrial Organic Solvents* by E. Browning.

It is a pleasure to acknowledge the fullest possible help that the authors of the various sections have given throughout. Their friendly collaboration has made my task as Editor particularly satisfying; indeed, had it not been for the unfortunate printing strike, this book would have been published in 1959.

I have to thank Dr J. Fowler and Dr R. D. Moore of King's College Hospital Medical School for many useful suggestions in matters of detail. I am also pleased to acknowledge my indebtedness to my colleagues on the Laboratory Handbook Sub-Committee and especially to Dr Gibbs and his staff in the Editorial Office of the Royal Institute of Chemistry. His wise guidance and the ever-ready help by his staff have made a pleasure of what otherwise might have been an irksome editorial burden.

The Editor and authors would be grateful to receive any comments as to ways in which the book can be made more useful in a future edition.

London,
May, 1960

C. H. GRAY

I. INTRODUCTION AND GENERAL PRINCIPLES

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"A serious toxic effect is not blunted because it was unexpected, nor is tragedy less painful because a danger was not anticipated. We can never be overcautious in demanding that substances proposed for human use be safe." Although introducing a discussion on potentially toxic substances encountered in everyday life, these telling words of the distinguished American toxicologist, W. Antopol, apply most aptly to the risks that face the laboratory worker from time to time by virtue of his occupation. Habitual contact with chemical and physical agents breeds in him a contempt for their potential dangers that can lead to tragedy, which may be all the more poignant because it could so easily be avoided. In this book will be found a detailed and authoritative account of laboratory hazards to health prepared by experts with a long experience of their special environment. It is not the purpose of the Editor and his contributors to rouse unwarranted alarm; nevertheless, a certain amount of straight speaking and facing up to unpleasant facts is necessary if the job is to be done well.

THE MAIN RISKS

As I see the problem, the risks are twofold. In the first instance, an accident occurs and harmful chemicals are spilled or noxious fumes are liberated. Hence the skin may be contaminated, the eyes spattered and the subject may inhale, in his panic, vapour that irritates or burns his air passages. With this set of mishaps should be included the catastrophe of swallowing a poisonous fluid during pipetting or some other procedure.

Let us look at these mischances a little more closely. Most of us have experienced the sharp pain and burning sensation that set in at once when strong acid falls on the skin, or the numbness succeeded by tingling that follows contact with some organic solvents. We know, too, how soon a crop of blisters spring up at the contaminated area and the certainty of infection if the part is not kept clean. Imagine the after-effects of a chemical burn to a large part of the body. Reddening and blistering are then intense, pain is continuous and severe, and the subject passes into a state of collapse that is indistinguishable from surgical shock. Much of the trouble now stems from the tremendous loss of fluid into the burned regions. Since this fluid comes mainly from the blood, the latter soon becomes dehydrated, thickened and difficult to keep circulating, and the heart may fail to beat normally.

Such serious effects must, of course, be given highly skilled medical attention. Even when the emergency has passed, unpleasant complications may arise from scarring of the damaged tissue, together with disfigurement and impairment of function if limbs or eyes are involved in the burning.

Consider, for a moment, too, the effects of inhaling irritant vapours such as acid fumes or ammonia. The sensitive membranes of the eyes and nasal cavities quickly redden as the blood-flow accelerates through their highly vascular textures, watery or slimy fluid pours out from the tissues into the adjacent cavities, and there may be bleeding from the membranes. But inhalation can be a much more serious business than this because the air passages are particularly susceptible to the action of fumes or irritating liquids and so rapidly swell up that the airway to the lungs can be greatly impeded. Sometimes the resulting asphyxia is so serious as to necessitate an emergency operation for the relief of the air block. Even when the local effects are not so startling the outcome may still be worrying, for the lungs are peculiarly susceptible to all such fumes and react violently in the form of pulmonary oedema or more slowly as bronchitis, or bronchopneumonia. And still more to be feared are lung abscess and gangrene, which make life a burden and are not infrequently fatal. We must not forget the chronic, debilitating conditions of the respiratory apparatus known as bronchiectasis and emphysema, which drag on for long periods of time, only to terminate quite often in heart failure.

Risks from swallowing dangerous fluids need no emphasis, for all of us are brought up with some knowledge of poisons. Their effects range from increased salivation, nausea, retching and violent vomiting, sometimes with the bringing up of blood and bile, with combined vomiting and diarrhoea and abdominal cramping pain, to attacks that recall severe food poisoning or even cholera. So much fluid, and contained salts, is lost from the body in this way that the patient rapidly becomes dehydrated and collapsed. Proper treatment is urgently needed and calls for the highest skill on the part of the physician.

The second risk springs from chronic poisoning through the insidious absorption of a toxic chemical by one or other route of entry into the body. When this goes on for months or years, a pattern of symptoms develops, based upon the prolonged and cumulative deterioration of a set of internal organs or tissues, that often defies medical diagnosis and treatment.

FACTORS THAT DECIDE THE OUTCOME OF TOXIC EXPOSURE

Each of these groups, in turn, is swayed by factors that decide the outcome of the episode in no uncertain fashion. Thus the amount of acid or alkali, its concentration, the speed with which it is neutralized or washed off and the presence of protective clothing obviously may

determine how serious the accident is if a limb is involved, but an acid splash in the eyes is followed by results that are out of all proportion to any such factor. So, too, a powerful reagent contaminating the lining membrane of the stomach or intestine may lead to immediate alarming results which, however, are much less important than the destruction it induces in internal organs, such as the liver or kidneys. Here the damage arises after the contaminant is absorbed into the blood and is carried to a vulnerable tissue where it kills off many vital cells. In some instances the action is more subtle, for the agent is converted into a by-product with a more specific and potent damaging action on the internal tissues than the parent poison. A strange example of this mode of action on the kidney is encountered, every now and then, with compounds that are rapidly detoxicated or metabolized after absorption, only to produce harmful metabolic derivatives. Ethylene glycol, for instance, a varnish ingredient, is much more toxic than its close relative, propylene glycol, simply because it is transformed into glycollic and then to oxalic acid. The latter, of course, is well known as a kidney poison. Propylene glycol, on the other hand, is broken down to lactic acid, which is innocuous. More often trouble comes about through an organ selecting and concentrating the poison. In that case minute amounts are abstracted from the blood, much of the solvent phase of which is withdrawn or the poison is transferred to other solvent phases within the tissue and highly toxic levels for that particular tissue are reached. Instances of this phenomenon are often encountered in the brain and the kidneys.

Some of the most astonishing instances of complex response originate in chronic poisoning. The insidious withering away of the conducting pathways of the nervous system may paralyse first one and then another activity or interrupt the co-ordination of a number of functions, with dire results to the individual. Such diseases have analogies in the blood-forming tissues of the bone marrow and in the reproductive organs. A steady reduction in the number of their functioning cells leads in time to a broad spectrum of disease. Thus disease of the bone marrow ranges over the anaemias and agranulocytosis on the one hand and the leukaemias on the other; reproductive disturbance culminates in infertility and perhaps distressing mutations and abnormalities of the offspring.

Clearly the toxicity problem is complex and unpredictable in its outcome. To some extent the effects may be forecast in terms of chemical or physical reactions between the agents and the proteins that make up so much of the body's framework. This, however, is an over-simplification, for the living organism has numerous defence mechanisms against noxious agents of every kind. Some of these we see in action in the form of symptoms and after-effects of poisoning. Thus the reddening of the skin, the catarrhal secretion from the nose, lower air passages and stomach and the red, weeping eyes represent

devices for neutralizing and flushing away the irritant material. So, too, the unpleasant skin irritation, blistering and infection, the scarring of body surfaces and internal organs, the oedemas and lymph gland enlargement fit into a scheme of defence which decides the fate of the patient.

We must be prepared, too, for another point of view about the dangers of internal absorption of a poison. When this goes on energetically, then the worst is to be expected, for much of a vital organ is speedily put out of action. But with slower absorption there is time for a certain amount of counteraction to occur. The poison kills off groups of cells in the liver or kidney without apparently disturbing the overall function. This is because nearly all organs carry a vast reserve of cells, most of which are not in action at any given moment and therefore are less vulnerable to the poison than those energetically performing their functions. Such an escape mechanism means, too, that something has been kept in reserve after the catastrophe is over. The surviving cells possess remarkable powers of reproducing themselves and so replace those that were killed off when the poison reached their neighbourhood. Practically every tissue in the human body has acquired the trick of regeneration after injury, with one outstanding exception, the nervous system, but here the reserve of nerve cells is so great that serious damage can often be put up with. Quite likely, destruction of cells is another way of anchoring a circulating poison to a locality where it is less liable to do as much damage as when it is allowed to range over the whole of the body tissues. Be this as it may, it is quite certain that many cells have effective ways of detoxicating poisons. This they do through the use of normal metabolic processes that can be diverted from their accustomed pathways in the cells to immobilize the unaccustomed agent or to convert it into a relatively innocuous product, which is then excreted at leisure without harmful side-effects. The mere storage of a toxic chemical is successful enough provided its dangerous action can be screened off, say, by masking the chemical with some natural product of cellular activity such as lipids, mucoproteins or collagen. Such is the case in lead poisoning, when absorbed lead salts are stored for long periods in bone without ill effects developing within the organism. But detach the lead from its organic bony screen by the administration of parathyroid extract and acute poisoning sets in when the accumulated lead re-enters the blood in mass.

UNUSUAL EMERGENCIES

A crisis may blow up in an altogether unexpected fashion, long after the acute emergency has been successfully weathered. Since this in itself is a vast and still largely unexplored territory of toxicology, I can do no more than indicate some interesting examples.

(1) Repeated exposure of a worker to toxic substances may lower the resistance of one or other of his tissues to bacterial infection with the imposition of a new disease picture. Certain naphthalene derivatives are known to act in this way on the skin of persons handling them repeatedly. The outcome is a set of unpleasant skin troubles that include acne, impetigo and furuncles, and the associated lymph glands may enlarge considerably. Other chemicals, notably chloroprene, cause the hair to become brittle and to fall out, with or without associated infection of the hair follicles. Repeated exposure to some detergents and other cleaning agents leads, as we all know, to distressing dermatitis of the arms and hands in some folk.

(2) We must expect more and more in the future the discovery of chemicals with highly selective actions on the tissues. As examples of this possibility we need only recall the localization of radium, uranium and lead salts in the bones, of organic arsenic in the liver and its bile passages, of pteridine in the heart muscle and of cadmium salts in the gonads. True, these are unusual, even bizarre, instances and perhaps remote from practical affairs, although modern experience with radioactive substances certainly cannot encourage complacency in man. The experimental production of leukaemias in animals by such diverse agents as ionizing radiations, methylcholanthrene, oestrogens, benzene and indole, placed side by side with clinical experience of radiation and fall-out, carries a warning that cannot be neglected.

(3) Since the classical investigations of Landsteiner we have grown accustomed to the idea that certain chemicals combine with the body proteins to form abnormal compounds which can then initiate antibody formation. From this unnatural combination come antibody–antigen responses that are of two distinct types. Some show up as immediate, rather alarming disturbances that vary from severe urticaria, through asthmatic attacks to anaphylactic shock. These are sometimes met with after the use of aspirin, penicillin, streptomycin, organic arsenicals and, indeed, many other chemicals. They are highly specific, and almost certainly act through an antibody–antigen reaction extracellular in location and which releases histamine from cells. The histamine diffuses throughout the adjacent tissue spaces and makes the tiny blood vessels more permeable to blood plasma, thus producing urticaria and skin rashes. When the lungs are involved asthma may follow. Other responses are delayed for about 5–14 days after the antibody–antigen reaction owing to slow penetration of cells by the antigen or to the formation of further antibody or to the gradual formation of substances that are responsible for the delayed allergy. The clinical features then include skin rashes of various kinds, destruction of the blood-forming cells of the bone marrow, and sometimes 'drug fever'. The

possibility of either form of allergy developing in laboratory workers cannot be ignored.

(4) Contact with carcinogens is, of course, a special risk that is nowadays deliberately sought out and, wherever possible, forestalled. All laboratories given over to cancer research have worked out their prophylactic routines suited to their own particular requirements. So, too, where radiation risks are encountered the need for protection is well understood and insisted upon. In the laboratory where these techniques are employed more or less casually a falling off in high safety standards is to be feared. The less-publicized carcinogens are, in my experience, sometimes passed over and safety precautions ignored even though the self-same agents are daily inducing tumours in laboratory animals. And perhaps a note of warning should be sounded about careless exposure to hormones of the corticosteroid variety.

(5) The importance of pre-existing disease in a worker, even though latent or overt, should not be underestimated. Proof that contact with poisons will stir up trouble in a man with stationary or slowly-progressing disease of the kidneys, liver or heart may be extremely difficult to obtain, since recognition of the association depends largely upon clinical acumen. It is otherwise with experimental animals. Toxicologists have long known that their well-planned tests are rendered valueless should a dormant infection become activated or a not very serious epidemic breaks out. A drug or chemical compound, too, can produce different effects in normal and diseased animals. Thus, from time to time, a dormant infection flares up after the administration of a drug such as cortisone or exposure to radiations. An animal with reduced kidney, liver or thyroid function may frequently display quite astonishing effects after a small dose of a drug; indeed, these often exceed those encountered in a normal animal with a much larger dose. So, too, animals carrying tumours are not uncommonly susceptible to liver damage produced by certain toxic agents. It may never be possible to establish the validity of this principle in man because of the large number of variables that cannot be controlled, but few who have worked in this field would deny its likelihood.

(6) A special place must be kept for disturbances of the central nervous system. A few chemicals are known to induce serious impairment of regions in the brain and spinal cord many months or years after exposure. And exposure need not be too prolonged, for there are cases on record where quite transient absorption has been followed by the outbreak of a chronic nervous disease. Whether the chemical agent itself is responsible or activates a latent infection is not yet known for certain.

The clinical features in these instances are manifold. Thus with carbon disulphide intoxication they include optic neuritis, with loss

of sight, polyneuritis and even Parkinsonism. Trichloroethylene is another poison that occasionally induces disturbances of vision, impaired sensory reflexes, tremors and ataxia. Other poisons lead to spastic paralysis, nystagmus, giddiness, headache, excessive sweating and fine tremors. Still another group, which includes methyl cellosolve, is unique in its induction of personality changes. The affected subject may pass from intelligence and quickness to stupidity and lethargy. Fortunately the number of cases that can be traced to laboratory accidents is still very small but that is no excuse for slackness in precautionary measures.

ACCIDENTS WITH FIRES AND REFRIGERATORS

Two other matters concerning laboratory risks merit attention. The first relates to fires in laboratories, the second accidents with refrigerators. Fires, of course, are serious enough, even in minor form, because they destroy living tissues or asphyxiate from inhalation of smoke and carbon dioxide; an associated leakage of gas adds the possibility of carbon monoxide poisoning. An unusual hazard sometimes arises when a fire extinguisher like carbon tetrachloride is used over-enthusiastically with the production of phosgene gas, which is well known to be a highly toxic lung poison that quickly leads to fatal pulmonary oedema. Some of the mixed halogen derivatives of methane in the Freon and Arcton groups of refrigerants are said to give phosgene and fluorine in contact with hot objects. Carbon tetrachloride itself in quite low concentrations possesses toxic properties and not a few casualties have been caused by misuse. It exerts its destructive effects mainly on the liver and kidneys, but it can seriously damage the heart and the brain, and even the blood. Another fire extinguisher and refrigerant is methyl bromide, which has an unpleasant reputation as a chronic nerve poison. However, invalidism arising from these sources is rarely encountered and the risks are potential rather than immediate. Nevertheless, there is no place for carelessness in their use.

SOME EXAMPLES OF TOXIC ACTION

So far I have discussed the principles of toxic action in more or less general fashion without much attention to details. It would seem fitting to conclude this introduction by selecting a few examples of chemicals whose misuse may lead to catastrophe, in order to emphasize their varied toxic properties and the consequent need for taking all such emergencies seriously. I will begin with a group of acids, then say something about carbon disulphide and hydrogen sulphide, glance at the chromates and conclude with nitrous fumes and cyanides.

Acetic acid in small drops induces serious burns of the cornea, painful conjunctivitis and occasionally iritis, so that vision may be

seriously affected or even lost. Intractable chemical burns have developed after spilling the strong acid on the skin, but the most serious effects result from ingestion, for the acid erodes the lining of the mouth, pharynx, oesophagus and stomach, and induces vomiting, diarrhoea and bleeding from the bowel. Absorption, too, may lead to suppression of urine and the loss of blood and albumin through the urine, for acetic acid injures the renal blood vessels and cells. Inhalation of fumes causes hoarseness and difficulty in breathing and, in the most severe cases, acute laryngitis, pneumonia and a possibly fatal oedema of the lungs. *Hydrochloric acid* is a more powerful corrosive agent than acetic acid, inducing very much the same, though more intense effects. Its vapour corrodes the cornea, the nasal septum and the bronchi. The respiratory disturbances are particularly unpleasant, for breathing becomes painful and laboured after acute exposure, and the late effects include chronic pneumonia, pleurisy, lung abscess and bronchiectasis. Strong *carbolic acid* (*phenol*) irritates the skin, leading to sensations of prickling and burning, followed by numbness and anaesthesia. Later the affected skin dies and is sloughed off, leaving behind a chronic ulcer that looks like a deep thermal burn. Phenol is absorbed through the skin, as from all mucous surfaces, thereby producing serious disturbances of the central nervous system, with intense headache, dizziness and ringing in the ears, and, in more severe cases, excitement, muscle twitchings, convulsions and finally coma. Respiration becomes shallow and rapid from the associated acidosis that accompanies severe kidney damage and disturbance of gastric and intestinal function, with loss of salts from the blood. Occasionally jaundice develops because of partial destruction of the liver. The clinical picture is thus one of infinite variety, and all too frequently terminates in fatal chronic nephritis. *Picric acid*, in contrast, mainly damages the skin, which becomes the site of various kinds of eruptions and occasionally a distressing exfoliative dermatitis. The skin rapidly turns yellow. When ingested in large amounts picric acid leads to inflammation of the stomach and upper intestine and is absorbed to induce severe nephritis and some injury of the liver. Contact with the eyes is followed by conjunctivitis, keratitis and yellow vision.

Both hydrogen sulphide and carbon disulphide are examples of toxic agents that lead to alarming nervous disturbances, especially when they are inhaled in high concentrations. *Carbon disulphide* irritates the skin and may blister it when exposure is prolonged. It is rapidly absorbed, perhaps because of its affinity for lipids, and leads to fatigue, slight visual disturbances, headache, forgetfulness and loss of memory. Sensory disturbances develop in different parts of the body, but the more remarkable features, especially after inhalation of high concentrations, are psychiatric in character. They range from irritability and depression to manic-depressive psychosis, often with a paranoid tendency. Parkinsonism and features suggesting a brain tumour also

occur. But the most common result of carbon disulphide poisoning is neuritis affecting the limbs and the optic and auditory nerves. In this way the clinical pattern does indeed become complicated, including symptoms as diverse as abnormal sensory sensation, progressive loss of strength in the limbs, abnormal colour vision, paralysis of accommodation, dizziness, tinnitus and nystagmus.

In low concentrations, *hydrogen sulphide* irritates all mucous membranes, inflaming the conjunctiva and cornea, irritating the nasal and lower air passages and inducing gastro-intestinal upset. High concentrations give depressant effects on the central nervous system, with death from paralysis of respiration. Somnolence, amnesia, unconsciousness, delirium and hallucinations, along with difficulty in swallowing, low blood pressure, double vision and epileptiform convulsions are then dominant features. Exposure to low concentrations over some weeks may be followed by headache, irritability, insomnia, loss of appetite, nausea and vomiting, with slowing of the heart rate.

Chromates are liable to induce dermatitis and skin ulceration. The ulcers heal rather slowly. Sensitization is not uncommon and leads to all of the allergic manifestations so well known in the nose and skin. Only with long continued absorption does serious disease set in but this may include ulceration of the stomach and intestine, anaemia, chronic hepatitis, cancer of the skin and lung and chronic nephritis.

Nitrous fumes consist essentially of nitric oxide and nitrogen dioxide. In high concentrations they discolour the skin, hair and teeth, corrode the conjunctivae and cornea, and produce severe irritation of the respiratory mucous membranes and lungs. Pulmonary oedema brings about death within a few hours to several days. With less severe exposures the clinical course is stormy, and the patient experiences difficulty in breathing and cyanosis, vomiting and giddiness —perhaps fainting—but pulmonary oedema does not occur, and recovery is usually complete. Rarely, the patient rapidly passes into a shocked condition, in which the circulation collapses, and death seems to be due to arrest of the blood flow through the lungs. Prolonged exposure to low concentrations may terminate in chronic bronchitis or bronchiectasis, but injury to the gastro-intestinal tract and the kidneys is rare.

Free *hydrogen cyanide* is a highly toxic gas which is readily absorbed through the lungs, the alimentary canal and the intact skin. Hence it exerts its effects at once and patients either die very rapidly from respiratory failure because the gas unites firmly with cell respiratory pigments, or quickly recover when efficiently treated. Prolonged exposure to low concentrations gives lassitude, headache, insomnia, skin eruptions and occasionally disturbances of vision and hearing. *Cyanides* can induce skin rashes which especially affect parts exposed to friction, and occasionally neuritis, gastro-enteritis and even intermittent central nervous disturbances.

No further pleading should be necessary to impress upon the reader the need to take this question of toxicity seriously. At the same time, undue alarm is uncalled for, since common sense and the taking of elementary precautions are sufficient safeguards in ordinary circumstances. Nevertheless, accidents do occur and mistakes are made in the best-regulated departments. Expert guidance, as set out in the following chapters, should enable the reader to deal with any such emergency.

II. PRECAUTIONS AND PREVENTIONS

II. PRECAUTIONS AND PREVENTIONS

In this chapter many aspects of safety that chemists usually take for granted are discussed. A laboratory, in addition to its being planned for the efficient conduct of whatever work has to be done in it, should also be designed with a view to eliminating accidents. In the context of this book, this applies with particular force to the more insidious dangers from toxic chemicals. Each laboratory will have its own special problems. Here, therefore, we are concerned, in the first place, with such general features of laboratory planning as will restrict the danger of contact with harmful chemicals to a minimum and then with suggesting means by which harmful chemicals can be handled with relative safety. Though some remarks on specific chemicals will be included, the discussion will, on the whole, be of a general nature. The hazards of handling radioactive material are being considered separately (*see* p. 151). Thus the account is not to be taken as an exhaustive study of the subject, and much of it reflects the personal views of the authors. It aims at giving assistance rather than definite instructions, for it is thought that each laboratory or organization should build up its own code of practice to suit local conditions.

LABORATORY PLANNING

Hard and fast rules for the design of chemistry laboratories cannot possibly be laid down, since the requirements of any laboratory will depend on the type of work to be carried out there. Nevertheless, certain general principles should always be observed if the maximum protection against toxic hazards is to be obtained. Ample light and adequate working space, together with careful attention to the disposition of work benches and other facilities, are perhaps the first essentials. Overcrowding and insufficient storage space, which can result in confusion of unused equipment and chemicals, always represent potential hazards.

Where a large volume of work with a particular toxic chemical is involved, then consideration should be given to the provision of small rooms apart from the main laboratory in which these operations can be carried out. Where large bulks of solvents are handled, as for example in banks of solvent extraction equipment, a separate room should be set aside and additional ventilation provided so as to reduce the vapour concentration; this in turn will reduce the toxic hazards as well as the inflammability hazard. Hydrogen sulphide is a reagent often used in considerable quantities in analytical laboratories and this should be isolated in a separate room. It is highly toxic as well

as having an objectionable smell, and the use of a manifold exhaust system to carry away the excess gas is recommended. This excess gas can then be burnt by leading it into the air supply of a gas jet so situated that the products of combustion are discharged outside the building.

Water supplies are essential in all chemistry laboratories, but it is surprising how often they are inadequate or inconveniently placed. Each working position should have a readily accessible sink with sufficient taps so that one is always available in emergency. The drains should be designed to carry away the maximum water flow and should be so disposed as to have a continuous fall to the outflow so that no stagnant pockets of effluent can be left. The type of trap to be adopted depends very much on personal choice and the type of work in the laboratory. The common domestic U-trap has little to commend it. A straight-down pipe with the lower end drowned in a gulley-trap is probably more satisfactory; the discharge from each trap can lead into a common gulley at floor level and thus be passed outside the building. This arrangement may not, however, be practicable where laboratories are made by reconstruction of existing buildings. Gullies or gutters of chemical stoneware or glazed earthenware should be inspected frequently to see that the jointing is in good condition and should be readily accessible so that they can be cleaned when necessary.

Good general ventilation is very necessary for all chemistry laboratories. This is often achieved by the use of a high, louvred roof, but where forced ventilation is required this should be by a positive pressure supply so as to assist rather than compete with the forced draught in fume cupboards. Three types of fume cupboard ventilation systems are commonly employed: hot-air-assisted natural draught (which is not very efficient), air ejector systems from either a compressed air supply or a separate low-pressure blower, and direct extraction fans. Air ejector systems can be designed to work satisfactorily, but they are in general very noisy and wasteful in using quantities of compressed air. They have been recommended where highly corrosive gases are likely to be present but modern methods of protecting fan blades from corrosion have made them unnecessary even for these purposes. Direct-extraction fans are undoubtedly the most satisfactory. They should preferably be mounted outside the laboratory so as to reduce noise, and the ducting to them should be as short and straight as possible without any sharp bends. The fan discharge should be carefully sited to avoid any danger that the fumes will be blown back into the building or adjacent buildings. Separate small fans for each cupboard are to be preferred to one large one into which a group of cupboards are manifolded, so that fumes from one cupboard cannot leak back into another. In this latter system a second danger is that the draught in any particular cupboard may suddenly be reduced below the safe minimum if too many of the other cupboard fronts are simultaneously opened. The cupboards themselves should be so

designed as to encourage their use, and where preparative processes are involved should have adequate head room to allow complex apparatus such as reflux and fractionating columns to be erected in them with ease. Hoods are very commonly used for the removal of less noxious fumes, but they are only really effective where a direct vertical uptake is fitted and a good thermal draught can be secured.

The choice of teak for bench tops, though traditional, has certain disadvantages unless very carefully seasoned wood is used. Any shrinkage of the timber in the warm and often dry atmosphere of the laboratory can give rise to cracks in the bench surface which are undesirable traps for spilled chemicals, especially mercury, and represent a potential toxic hazard. Laminates faced with melamine, such as Formica, make very good surfaces for bench tops and can be easily kept very clean. They are hard-wearing and can be obtained in sheets large enough to avoid any joints. A dark colour is preferred because of the possibility of staining with organic reagents. Acid-resisting tiles set in a minimum of acid-resisting cement also make a very suitable bench-top. Sindanyo makes a good material where the benches are subject to excessive heat, but it is less easy to keep clean and is somewhat absorbent, especially after long use. Where special cleanliness is essential, then Vitreolite is probably the most suitable, provided its poor heat resistance is acceptable.

Bench fittings should be as uncomplicated as possible. Much will depend upon the function of the bench itself, but the classical idea of a bench with a raised stand in the middle carrying a standard set of reagent bottles is very rarely an ideal arrangement. Many of these bottles contain toxic or corrosive chemicals which are not necessarily used with any frequency. There is much to be said for a flat-topped bench with no fittings other than the normal services at the back of the bench, the controls being at the front below the level of the bench top. Reagent bottles can with advantage be in trays, designed to contain spillages, which can be moved when not required (the selection of reagents in each tray depending on the work in progress). Reagents that have to be stored on shelves should be so arranged as to be accessible to the operator, who should not have to reach across the bench for them.

Laboratory flooring always presents something of a problem. Wooden floors are not really satisfactory as they are neither resistant to spillages nor completely impervious. Concrete or tile floorings are ideal but very tiring to work on continuously. An impervious rubber flooring or properly laid linoleum are probably the most satisfactory as well as easy to keep clean. Polishing of laboratory floors is not normally advisable.

The provision of protective clothing, eyeshields and face-masks will be discussed later. All protective equipment should be readily available in each laboratory and should be kept in a specific place set apart

for the purpose—such as a glass-fronted cupboard painted green—which is known to all persons working in the laboratory. First-aid equipment should also be provided nearby (*see* p. 33). After use the equipment should be washed and dried and returned to the cupboard ready for the next user. Any defects should be reported immediately so that they can be made good by the issue of new equipment.

LABORATORY SAFETY OFFICER

In each laboratory a competent chemist should be appointed as Laboratory Safety Officer, with a Deputy. They must be familiar with accident procedure and responsible for maintaining the first-aid box, protective clothing and other safety equipment. In a school laboratory the L.S.O. would be a member of the teaching staff and the laboratory steward might be trained as deputy.

Many large organizations have systems of reporting accidents which will cover accidents with toxic chemicals, and most industrial laboratories are required by statute to keep records of accidents involving injury to personnel. Such records are of value in that when examined and analysed at intervals, they may disclose aspects of safety precautions which are defective and require either reconsideration or more strict enforcement. The Royal Institute of Chemistry is always interested to receive accounts of more unusual accidents and occurrences so that they can be published in the *Journal*. By this means, a wider public can be made aware of unexpected hazards and thus a repetition be prevented.

GENERAL SAFETY PRECAUTIONS

It is generally recognized today that every laboratory or group of laboratories, however small, should have a set of safety rules which are appropriate to their particular type of work. These should take into account the toxic hazards of the materials handled, and in this section some of the more important points which should be included are considered.

Any chemicals spilled on the hands or other parts of the skin should be immediately washed off. This should be done with toxic and non-toxic chemicals alike, so that the practice becomes automatic. If this is not done, there is always the danger that their presence may be forgotten and subsequently they may unthinkingly be transferred to the mouth. Similarly, many chemicals have an irritant effect on the skin, causing dermatitis, and they should be removed for that reason. Solvents should not be used, since they may in fact accelerate the absorption of the chemicals it is desired to remove and may themselves damage the skin by their degreasing action. Any chemicals that cannot be removed by water should first be treated with one of the many available emulsion cleaners, followed by plenty of soap and water. Barrier creams are useful against dermatitis-producing chemicals and where contact with the skin is unavoidable. Individuals vary

greatly in their susceptibility to the irritant action of chemicals, which gives rise to dermatitis in many subjects. Where prolonged handling of a certain chemical is accompanied by outbreaks in the skin, dermatitis should be suspected and special care taken in future. Even when the irritation has ceased, it should be remembered that sensitization has probably occurred and even brief contact may bring about a recurrence of the symptoms.

Chemicals are more rapidly absorbed into the system through open wounds than through the intact skin, and all cuts or scratches should be protected by suitable dressings or if necessary by the use of rubber gloves.

The consumption of food or drink in chemistry laboratories should be absolutely forbidden. The danger of accidental contamination of food should be perfectly obvious to anyone working in a laboratory, and the practice of drinking tea, which takes place in many laboratories, though less objectionable, should not be encouraged. It is far safer to set apart for this purpose an office or mess room where there are no chemicals.

It is far more difficult to generalize on the question of smoking in laboratories. There are clearly many chemical processes, such as those in analytical work, where the presence of tobacco smoke is undesirable on general principles. It may not always be realized that comparatively harmless materials can be converted into dangerous toxic ones on passage through the hot zone of a cigarette. For example, chlorinated hydrocarbons, such as trichloroethylene, produce phosgene on partial oxidation. Very small quantities of some fluorine compounds, such as polytetrafluoroethylene, have been known to get mixed with tobacco and on subsequent smoking give rise to symptoms similar to those of acute influenza within 2 or 3 hours. It would thus seem advisable to limit smoking in laboratories, especially those in which organic chemicals and solvents are handled.

When processes involving toxic chemicals are to be carried out, it is often inadvisable for the operator to be working in a laboratory by himself. Depending on the scale of operations, or the extent of the hazard involved, it may be sufficient for a second person to look in at intervals to see that all is well. Where the potential danger is high, a second person in the room would be ready on the spot to take immediate action in event of an emergency. In either case it is essential that the nature of the materials being used should be clearly understood by someone other than the operator so that the appropriate emergency action may be taken. These points should be borne in mind when arranging for the working of overtime.

For the same reason, students and junior staff should have impressed upon them the dangers of carrying out unauthorized experiments. While it is clearly not desirable to discourage legitimate initiative, the dangers of forming toxic gases or vapours should be emphasized. The

gases evolved in qualitative analysis should not be inhaled deeply; a cautious sniff is safer and just as informative.

Chemicals used for laboratory experiments are not subject to the provisions of the Poisons Acts. Nevertheless, scheduled poisons are usually labelled as such and these are the only agents described as poisons in Section IV. It is essential that a close control should be kept on the most dangerous, such as cyanides. These should be in the charge of a responsible person and should be issued only when required for specific experimental purposes and then only in the quantities immediately required. Any material transferred to a secondary container should be clearly labelled so as to prevent mistakes. Everyone handling such scheduled poisons has a moral obligation to ensure that they are not improperly used and do not go astray, with possible serious consequences.

SPECIAL PRECAUTIONS

In the previous section, some of the general precautions for the avoidance of toxic hazards were discussed, many of which are really a part of normal laboratory discipline. In this section some special points to be remembered when handling toxic chemicals are considered. To discuss in detail the precautions necessary for each type of toxic agent would be both lengthy and repetitive. The information given in Section IV defines clearly the potential dangers, and the types of protection and preventive action to be taken can be deduced from them. It will be noted that a distinction is made in the level of risk by the use of the words 'avoid' and 'prevent'. For example, 'avoid' is used where contact with the skin is clearly undesirable but because of the slow rate of absorption or attack on the tissue, the wearing of gloves would not be essential when handling small quantities, provided that any splashes were immediately washed off. If, however, the same chemical were handled in quantity, then clearly gloves would be advisable. Where 'prevent' is used, then protection should be considered as obligatory even when handling small quantities of the chemical if there is the slightest possibility of splashing. It must be for the operator or supervisor to decide what is the extent of this possibility. Even though contact between the skin and hydrofluoric acid must be prevented, it is daily handled without gloves in analytical laboratories and with no serious consequences, because the quantity used for any one operation is rarely more than a few millilitres. Nevertheless, if any large-scale preparative use were under consideration the wearing of both gloves and a face mask would then be essential.

It is probably a sound principle to limit the compulsory use of protective clothing to those operations where it is absolutely essential. Its use is, in general, not popular, because it is always somewhat restrictive and hampers freedom of movement; instructions for its use are more likely to be obeyed when it is realized that it is done for

the good of the operator and not as a pedantic precaution. Nevertheless, no-one should ever be discouraged from using protective equipment if he feels more confident when doing so. There is often a tendency for senior staff to claim that experience can replace the necessity for personal protection. This is most regrettable, as the example of senior staff can be the major factor in impressing juniors that regulations for its use are sensible and designed for the protection of the operators.

The main point to remember about protective clothing is that the easier and more comfortable it is to wear the greater the likelihood of its being used. Cumbersome and unnecessarily restrictive clothing should be avoided unless absolutely essential. Eyeshields and face-masks which stand well clear of the face and are adequately ventilated are to be preferred to close-fitting goggles. Rubber or PVC gloves, which are easy to slip on and off, are more likely to be used for such operations as handling strong acids and alkalis than close-fitting surgical ones, which, however, should be available where careful manipulation of apparatus has to be carried out with protected hands. When carrying large quantities of strong acids and other potentially dangerous materials, the use of suitable baskets is recommended. Specially designed polythene carriers are now available for holding Winchester quart bottles.

The provision of respirators will depend on the type of work being carried out. In normal laboratories, where only small quantities of toxic gases are being handled, emphasis should be placed on fume cupboards and good ventilation for protecting personnel. Siebe Gorman Mark IV respirators, which prevent the inhalation of dust, should always be available when handling finely powdered chemicals in bulk or when conducting grinding or sieving operations.

Since, in many instances, it is not only a question of protecting the individual operator but also other people working in the same room, fume cupboards or other type of protection around the equipment should be used whenever possible. It is probably true today that, apart from incidents arising from careless handling in transferring chemicals from one container to another, the greatest hazard arises from the inhalation of toxic vapours and gases or the splashing of chemicals over the laboratory by excessively violent behaviour of the contents of a reaction vessel. An efficient fume cupboard affords complete protection against the first of these, and transparent portable safety screens that can be easily erected round a piece of apparatus and dismantled on completion of the process will go far to reduce the second of these hazards.

The dangers of many laboratory processes are not always realized, even by experienced chemists. It is a common practice in almost all laboratories to remove solvents by evaporation in the open. Even if the fire risk is ignored, the toxic hazards can be quite considerable, as the chronic effects of inhalation of even small quantities of, say,

benzene vapour over a long period are very serious. If evaporation rather than distillation is essential it should be carried out in a forced draught, either in a fume cupboard or in a special solvent room as discussed above (p. 15).

Electroplating baths give rise, not to vapours, but to aerosol dispersions of the plating solution produced by the gases evolved at the electrodes. With cyanide baths this danger is obvious, and with chromium plating baths the danger is well recognized. For other plating baths, however, such as nickel and the fluoroborate baths now used for lead and other metals, this aspect may not be so frequently borne in mind. It is advisable that all plating baths, unless very small and infrequently used, should be provided with extra ventilation ducts, which can be conveniently placed behind the bath so as to draw air across the surface of the liquid and away from the operator.

Toxic chemicals and their solutions should never be pipetted by mouth. When small quantities only are involved, a Pasteur pipette should be used, but for larger quantities or precise work several types of safety pipette are now available from laboratory suppliers. One type resembles a hypodermic syringe, in that the suction is created by the action of a ground-glass piston running in a closely fitting cylinder. A simpler but equally effective one consists of a conventional pipette, to the top of which is fitted a large rubber bulb having three valves, which are operated by the fingers to control the liquid flow; solutions can be pipetted safely with the usual accuracy.

Mercury is perhaps one of the most casually handled chemicals in many laboratories, and yet its vapour can give rise to serious effects, both chronic and acute. There is some difference of opinion as to the danger of leaving dirty mercury around the laboratory either in open beakers or, as often happens, in cracks and crevices as a result of spillage. It is claimed by some writers that the vapour pressure is very much reduced by the layer of oxide normally present on dirty mercury. Nevertheless, it is good practice to ensure that all spills of mercury are cleaned up without delay and that dirty mercury is kept under dilute sulphuric acid while awaiting cleaning and distillation. When mercury-vapour diffusion pumps are used in high-vacuum equipment, cold traps should be installed on the discharge side of the pumps to prevent mercury vapour being pumped into the atmosphere. As an alternative, the pump discharge can be led outside the laboratory. If pumps are left running unattended, a safety switch should be incorporated to cut off the heating to the pump when the cooling water fails. This will also prevent excessive discharge of mercury vapour into the atmosphere. It should be remembered that mercury is a cumulative poison and can give rise to serious effects after exposure to small concentrations over a very long period.

Although not common reagents, toxic gases such as chlorine or carbon monoxide are occasionally used as compressed gas in

cylinders. When using such gas cylinders, the normal precautions for use of compressed gases should be observed, but on account of their toxicity it is inadvisable to leave them overnight in a laboratory, as a slight leakage from the valve could very quickly build up a highly dangerous concentration in an unventilated room. Care should be taken to check the valve out of doors before a cylinder is first taken into use to ensure that it can be operated easily and can be shut off tightly without leakage. Such cylinders should be used whenever possible in a fume cupboard, so that any leakage of gas due to malfunctioning of the apparatus can be rendered harmless to the operator.

Finally it is advisable to consider what steps should be taken to dispose of waste toxic chemicals. In most laboratories the quantities involved should not be more than can be washed down the normal service drain with a copious flow of water. Care should be taken that no untoward reaction between waste materials occurs in the drains with the generation of noxious or toxic gases. Cyanides are probably the most unpleasant chemicals to dispose of as waste, and when large quantities are involved they should be first precipitated with iron salts so as to render them harmless and insoluble. The local authority should be consulted before any large quantities of waste toxic material are discharged into the main sewerage system, since the acceptability or otherwise of such a procedure will depend on the type of sewage disposal system employed.

III. FIRST AID IN THE LABORATORY

III. FIRST AID IN THE LABORATORY

To be effective, first aid measures must be simple and capable of quick application. Criticism on the grounds of over-simplification is preferred to recommending treatment that is difficult to administer by unskilled hands and beyond the resources of most laboratories.

The order of presentation of first-aid treatment adopted here, *i.e.* inhalation, eye contact, skin contact, mouth contact and ingestion, is the same as that used in the description of effects in Section IV.

Removal from exposure occurs as a recommendation for treating all inhalation casualties, and this is the essential first step. Though seemingly obvious, it can easily be forgotten in an emergency. Resting and keeping warm are always prescribed because shock so often follows even mild gassing. Resting must be interpreted as laying the subject flat with feet raised slightly, clothing being loosened to ensure ease of breathing. Cases of mild shock are helped by giving coffee or tea to drink, but alcohol must not be given without medical approval; recommendations about stimulants are not made in the individual entries. When irritant gases or vapours have been inhaled, some relief may be obtained by inhaling over a vessel of hot water with or without Friar's balsam.

The decision whether or not to summon medical attention rests with the person looking after the casualty. With mild gassing, as might occur when a laboratory worker inhales an uncomfortable whiff of ammonia or hydrogen chloride, it can be alarmist to summon a doctor or send the patient to hospital. However, it is preferable to err on the side of caution, and medical attention should be obtained if any doubt exists.

The form of medical attention obtained depends upon local circumstances, and in the majority of cases prompt despatch of the patient to hospital by car or ambulance is probably the wisest action.

The Association of British Chemical Manufacturers (86, Strand, London, W.C.2) supplies special prepared labels for 'gassing' casualties that are sent to hospital with the patient for the guidance of the medical officer in charge. These labels are published by the Association in a booklet entitled *Gassing Casualties* and cover some 47 of the gases and vapours most frequently encountered in industry. The use of these labels in laboratories where the gases are used to any extent is strongly recommended.

With eye, skin and mouth casualties, water is invariably the first requirement. Fortunately this is immediately accessible in every laboratory and is widely advocated for nearly all acid and alkali

accidents in preference to the mild alkali and acid remedies that commonly feature in laboratory first-aid equipment.

Irritation of the eyes by vapour may not call for medical attention in all cases, but splashing of the eyes with any irritant liquid must always be taken seriously, and after first-aid treatment (outlined below) demands medical attention. Very prolonged irrigation of affected eyes by water is advised by some medical authorities. This is clearly important in some cases, but the severity of the irritant and the degree of contact, whether with vapour, liquid or solid, make it difficult to lay down hard and fast rules for the time of irrigation that is desirable. In cases of moderate severity 15 minutes is often advocated. Thorough irrigation is best achieved with an eye fountain, but if an eye bath is the only provision made, it is important that the water should be changed after each washing. When irritation is very severe, and the casualty cannot open his eyes voluntarily, he should be made to lie on his back and water poured into the eyes held open by thumb and forefinger. A suitable 16-oz eye-irrigation bottle, which can be part of the laboratory first-aid outfit, is illustrated below:

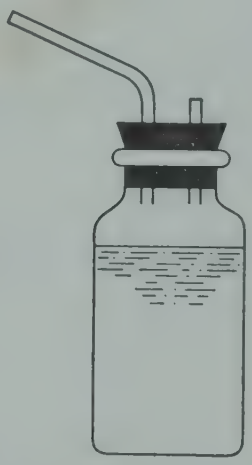

FIG. 1. 16-oz lotion bottle for use in the first aid treatment of caustic soda burns in the eye

Drenching with water is advocated as the first step in all cases of skin contact, and this is followed by soap and water washings where the toxic agent is not appreciably soluble in water. In the case of chemical burns of the skin a wet lint or gauze dressing, held in position by adhesive tape or a bandage, should be applied after washing the affected area thoroughly; this will protect the affected area until professional treatment is obtained. Dry dressings are used for heat burns. The need for removing and washing contaminated clothing before re-use is stressed.

Except for the suicide attempt or accidental drinking from a beaker or other vessel that was assumed to contain water, swallowing of toxic

materials is rare. Irritant substances taken accidentally by mouth provide their own warning and will be spat out instinctively before reaching the throat. However, it has been considered advisable to assume some swallowing in all cases of mouth contact. For all mouth contacts, thorough rinsing of the mouth with water is the important first treatment.

The effect of most corrosive materials, if swallowed, is greatly reduced by dilution; hence the advice to give plenty of water to drink in these cases. Milk of magnesia is recommended as the best antacid when corrosive acids have been swallowed.

EMETICS

Opinion is somewhat divided on the type of emetics to be used when poisonous substances have been swallowed. The response of different people to the various first-aid methods used to induce vomiting is by no means uniform. A useful and quickly available emetic is salt water (one tablespoonful of common salt in each tumblerful of tepid water) repeated until vomiting occurs. Another simple method is that of tickling the back of the throat with two fingers or a spoon. **It is emphasized that vomiting should never be induced in cases of unconsciousness or the ingestion of corrosive poisons, such as strong acids or alkalis or phenolic substances.**

UNCONSCIOUSNESS

Unconsciousness is not likely to be a frequent consequence of the ordinary laboratory use of narcotic substances, but there is always the possibility, even though remote, that an accidental explosion causing the escape of narcotic solvent vapours, or the swallowing in error of a liquid not recognized as poisonous, might result in such a condition. Figure 2 shows the prone or coma position in which an unconscious person should be placed until consciousness is regained.

It is important that no fluids should be given to an unconscious person.

ARTIFICIAL RESPIRATION

If unconsciousness is complete and breathing has stopped, artificial respiration should be applied immediately. Until recently Schafer's method was almost universally recommended and is still is use, but it has now been to a great extent superseded by the Holger-Nielsen method, now recommended by the British Red Cross Society as the method of first choice. By courtesy of the St John Ambulance Association, the St Andrew's Ambulance Association and the British Red Cross Society, the text and diagrams describing this method are reproduced below from the publication *First Aid* (First Edition, 1958).

Whenever artificial respiration is indicated, lose no time—every second counts.

Turning

If the casualty is lying on his back turn him to the prone position (face downwards) as follows. Cross his far leg over the near leg. Go down on the left knee opposite the casualty's head, placing the right foot on the ground out to the side.

Place the casualty's arms carefully above his head and keep them there during the turn.

Grasp his right upper arm and turn him over, protecting his face with the other hand. Adjust the position of the casualty's hands as instructed below.

Note: The above instructions can be reversed if necessary.

Position of the Casualty

Lay the casualty in the prone position on a flat surface.

Place the casualty's hands one over the other, under his forehead. The head must be turned slightly to one side. The nose and mouth must be unobstructed.

Position of the Operator

Place one knee with the inner side in line with the casualty's cheek six to twelve inches from the top of his head.

Place the other foot with the heel in line with the casualty's elbow.

FIG. 2. Position of Casualty and operator

Place the hands on the casualty's back with the heel of the hands on the lower part of the shoulder-blades, the thumbs alongside the spine, and the fingers pointing to the casualty's feet (Figs. 2 and 3).

FIG. 3. Position of Casualty and Operator (diagrammatic)

Movement (1)

Keeping the arms straight rock gently forward until the arms are ʌertical or almost vertical depending on the build of the casualty or that of the operator, using no special force. The movement takes 2 seconds counting 'one, two'. This pressure causes expiration (Fig. 4).

FIG. 4. 1st Movement Count 'One-Two'

Movement (2)

The operator now rocks back counting 'three' for one second and slides his hands past the casualty's shoulders until they can grip his upper arms near the elbows (Fig. 5). He raises and pulls on

the arms until tension is felt for a period of 2 seconds counting 'four, five'. He should take care not to raise the chest from the ground.

FIG. 5. 2nd Movement Count "Three"

This movement causes inspiration. The operator's arms should remain straight for the whole period (Fig. 6).

Counting 'six' for one second the operator lowers the casualty's arms to the ground and replaces his hands in the original position.

The whole operation occupying 6 seconds (that is, ten times a minute) should be rhythmic in character and be continued until breathing recommences.

FIG. 6. 3rd Movement Count "Four-Five"

When the casualty begins to show signs of breathing the operator should continue with movement 2 only, raising and lowering the arms alternatively counting 1, 2 (2 seconds) for inspiration and 3, 4 (2 seconds) for expiration (Fig. 6).

Summary of Counting and Timing

The counting and timing are as follows:—

ONE—TWO (2 seconds)—back pressure.
THREE—(1 second)—sliding hands to arms.

FOUR—FIVE (2 seconds)—raising arms.
SIX (1 second)—sliding hands to back.

The total count occupies six seconds which is *ten times a minute.*

Note: Opinions vary regarding methods of counting and timing. It is, however, considered easier for the student to keep to a regular rhythm based on 'the second' and for this reason the above method has been adopted in this manual."

LEGAL REQUIREMENTS FOR FIRST AID

Certain industrial laboratories must observe The First-aid Boxes in Factories Order, 1959, which requires that there shall be provided in readily accessible positions a sufficient number of clearly labelled first-aid boxes or cupboards. Each first-aid box or cupboard shall contain, where the number of persons employed exceeds ten but does not exceed fifty:—

(i) A copy of the leaflet giving advice on first-aid treatment (Form 1008) issued by the Ministry of Labour and National Service.

(ii) A sufficient number (not less than twelve) of small sterilized unmedicated dressings for injured fingers.

(iii) A sufficient number (not less than six) of medium-sized sterilized unmedicated dressings for injured hands or feet.

(iv) A sufficient number (not less than six) of large sterilized unmedicated dressings for other injured parts.

(v) A sufficient number (not less than twenty-four) of adhesive wound dressings of an approved type and of assorted sizes.

(vi) A sufficient number (not less than four) of triangular bandages of unbleached calico, the longest side of which measures not less than fifty-one inches and each of the other sides not less than thirty-six inches.

(vii) A sufficient supply of adhesive plaster.

(viii) A sufficient supply of absorbent sterilized cotton wool in half-ounce packets.

(ix) A sufficient supply of approved eye ointment in a container of an approved type and size.

(x) A sufficient number (not less than four) of sterilized eye-pads in separate sealed packets.

(xi) A rubber bandage or pressure bandage.

(xii) Safety pins.

ADDITIONAL PROVISIONS

It is suggested that in addition to the above provisions, which cater primarily for cuts and heat burns, each laboratory first-aid box should contain the following:—

16-oz eye irrigation bottle (*see* p. 28) and/or eye bath.
Tablespoon.
Bottle of common salt.
Bottle of magnesium sulphate (Epsom salts).
Bottle of milk of magnesia (dose—two tablespoonfuls).
Bottle of vinegar or 1% acetic acid.

The following remedies and antidotes for specific poisons should be included in the box if these poisons are being handled in the laboratory concerned:—

Bromine, Formic Acid and Hydrofluoric Acid (for application to splashed skin):

A 12-oz bottle containing dilute ammonia solution (1 volume 0·88 s.g. ammonia added to 15 volumes of water).

Cyanides (antidote to be taken when cyanides have been swallowed):

The following solutions must be made up and kept ready for immediate use—

A. 158 grams B.P. ferrous sulphate crystals ($FeSO_4.7H_2O$) and 3 grams B.P. citric acid crystals dissolved in a litre of cold distilled water (the solution must be inspected regularly and replaced if any deterioration occurs).

B. 60 grams anhydrous sodium carbonate (Na_2CO_3) dissolved in a litre of distilled water.

50 ml of solution A is placed in a 6-oz wide-necked bottle closed by a polythene-covered cork and labelled clearly 'CYANIDE ANTIDOTE A'. 50 ml of solution B is similarly bottled and labelled 'CYANIDE ANTIDOTE B'. Both bottles should bear the legend 'Mix the whole contents of bottles "A" and "B" and swallow the mixture'.

Hydrogen Cyanide and Nitriles (for inhalation by gassing casualties):

Amyl nitrite capsules (3 minims).

Iodine (for skin contact and ingestion):

Sodium thiosulphate crystals in bottles for fresh preparation of 1% solution in water.

Phosphorus (for application to skin burns):

12-oz bottle containing a 3% solution of copper sulphate in water.

IV. POISONOUS AND CORROSIVE GASES, REAGENTS AND SOLVENTS

IV. POISONOUS AND CORROSIVE GASES, REAGENTS AND SOLVENTS

This section describes briefly the harmful properties and effects upon the human body of over two hundred poisonous and corrosive materials commonly used in industrial, research and teaching laboratories.

The gases, reagents and solvents included have been restricted to those in fairly general use. Materials important only to specific industries, and less common reagents used mainly in research, or only in very small amounts, do not appear. Certain common solvents, such as acetone, cyclohexane, ethanol and the petroleum ethers, are not dealt with since the main laboratory hazard associated with them is inflammability, which is not considered to be the province of a handbook concerned with toxicity.

The fact that a material is not included does not mean that it is harmless. To devote space to the large number of substances with low toxicity would greatly increase the size of this section, thereby reducing the speed of reference to the first-aid treatment needed after an accident with a dangerous material.

The British Standards Institution's *Recommended Names for Chemicals used in Industry* (B.S. 2474 : 1954) has been followed throughout. Cross references are used extensively to cover the survival of many older names, and more obscure synonyms are also given after the main headings.

WARNINGS

Because the handbook also aims to help those who are wise enough to consider beforehand the risks associated with the materials they are about to handle, the system of using bold type warnings and injunctions has been adopted. This follows closely the pattern recommended in the excellent booklet *Marking Containers* published by the Association of British Chemical Manufacturers. Although responsible suppliers of hazardous chemicals include such warnings on the labels of their containers, the contents frequently find their way into other bottles and flasks. It would add to laboratory safety if these secondary containers were similarly labelled, and it is hoped that these warnings will prove useful for the purpose. For this reason 'HIGHLY INFLAMMABLE' (flash point below 73°F) and 'INFLAMMABLE' (flash point 73°F–150°F) warnings have been included where they apply. The use of the warning 'POISON' is limited to those materials covered by the Pharmacy and Poisons Act, 1933.

EFFECTS

The use of less familiar medical terms has been avoided as far as possible in describing the effects of dangerous materials. Short explanatory notes on the meanings of the terms that it has been found necessary to use are given in the glossary at the end of the book (p. 169). Where the information is available, chronic effects (those produced on prolonged

exposure to small amounts of toxic materials) are included as well as the acute effects. The effects are normally listed in the order inhalation, eye contact, skin contact, mouth contact and ingestion.

The literature drawn upon in trying to present a reasonable account of toxic effects does not always cover all the possible accidents that might occur. This is particularly true of mouth contact or ingestion, and where evidence is lacking certain effects are assumed. The rash and faulty use of an ordinary pipette to measure a volume of a particular corrosive acyl chloride may not have occurred in the past, but one day it will—and it seems wise to anticipate probable effects and prescribe commonsense first-aid treatment for a case of mouth contact and swallowing. Several types of safety pipettes are now available, and there is much to be said for their adoption wherever possible.

The use of protective clothing, gloves, goggles, respirators and so on is discussed in the chapter on 'Prevention and Precautions' (p. 20). The point at which the quantity of a dangerous material that is being handled necessitates the wearing of protective clothing and equipment will always be a matter of debate. How many university laboratories would insist upon a student wearing rubber gloves, let alone a respirator, when he is pouring a few ml of bromine into a test-tube? Teaching laboratories are the school for first-hand experience in handling dangerous materials at a low level of risk.

Because the level of risk varies so widely in different laboratories, it is not possible to prescribe protective wear under each individual material. Injunctions are shaded by using the word 'prevent' instead of 'avoid' when the danger from, say, skin absorption is of a high order and the wearing of gloves becomes more important. Familiarity with the chapter on 'Prevention and Precautions', together with the warnings and injunctions for the material to be handled, should tell the laboratory worker or his supervisor when and what protection is appropriate. However, in a few cases reference is made to special protection that is required.

PROPERTIES

The authors are particularly conscious of the compromises that must be made in the interests of clarity, conciseness and speed of reference in a handbook of this kind. These characteristics are vital in an emergency. The temptation to list more of the physical properties of a toxic material than will assist rapid identification by the person confronted with a casualty has been resisted. Melting points and boiling points are deliberately passed over in favour of short qualitative descriptions of appearance, volatility and smell. Water plays a vital role in first-aid measures and reference is therefore made to the solubility, miscibility or reactivity of the material with water. As a guide to those planning to use volatile materials regularly in some laboratory operation, the maximum allowable concentration (M.A.C.) of vapour expressed in parts per million of air per light-hour day of continuous exposure is included where this has been recorded.

ACETALDEHYDE (ACETIC ALDEHYDE; ETHANAL). Colourless liquid with pungent fruity odour; miscible with water.

HARMFUL, IRRITANT VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with eyes.
M.A.C. 200 p.p.m.

Acute Effects

The vapour causes irritation of eyes, headache and drowsiness.
The liquid, if swallowed, causes severe irritation of the digestive organs and drowsiness.

Chronic Effects

Repeated inhalation of vapour can cause anaemia, delirium, hallucinations, loss of intelligence, etc., as in chronic alcoholism.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ACETIC ACID. Colourless liquid with pungent acid odour; glacial acetic acid freezes to a crystalline solid in cool weather; miscible with water.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS
INFLAMMABLE

Avoid breathing vapour. Avoid contact with eyes and skin.
M.A.C. 200 p.p.m.

Acute Effects

The vapour irritates the respiratory system.
The vapour irritates and the liquid burns the eyes severely.
The liquid is very irritating to the skin and can cause burns and ulcers.
If taken by mouth causes internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove contaminated clothing and wash before re-use.
If swallowed: wash out mouth thoroughly with water and give water to drink followed by milk of magnesia; obtain medical attention.

ACETIC ANHYDRIDE. Colourless liquid with strong acid odour; reacts slowly with water to form acetic acid.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS
INFLAMMABLE

Avoid breathing vapour. Avoid contact with eyes and skin.
M.A.C. 5 p.p.m.

Acute Effects

The vapour irritates the respiratory system.
The vapour irritates and the liquid burns the eyes severely, with delayed damage.
The liquid irritates and may burn the skin severely, with blistering and peeling.
If swallowed, causes immediate irritation, pain and vomiting.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; give soothing drinks to relieve throat irritation.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove contaminated clothing and wash before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

ACETONE CYANOHYDRIN. Colourless liquid; miscible with water.

POISON
EXTREMELY HARMFUL VAPOUR
LIBERATES POISONOUS HYDROGEN CYANIDE
INFLAMMABLE

Do not breathe vapour. Avoid contact with skin and eyes.
M.A.C. 10 p.p.m.

Acute Effects

High vapour concentrations, if inhaled, rapidly cause giddiness, headache, unconsciousness, convulsions; in severe cases, breathing may cease due to hydrogen cyanide poisoning.
It must be assumed that skin absorption and taking by mouth will have similar effects.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; if breathing, break capsule of amyl nitrite and give to inhale for 15–30 seconds; repeat every 2–3 minutes. Apply artificial respiration (p. 30) if breathing has stopped; obtain medical attention.

Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: give cyanide antidote (p. 34); obtain medical attention.

ACETONITRILE—see METHYL CYANIDE.

ACETYL BROMIDE. Colourless to yellow liquid; decomposed by water with formation of hydrobromic acid and acetic acid.

HARMFUL, IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with skin and eyes.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates the eyes severely.
The liquid burns the skin and the eyes.
If taken by mouth, there is immediate and severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink, followed by milk of magnesia; obtain medical attention.

ACETYL CHLORIDE. Colourless, fuming, volatile liquid with a pungent odour; rapidly decomposed by water with formation of hydrochloric acid and acetic acid.

EXTREMELY HARMFUL, IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS
HIGHLY INFLAMMABLE

Avoid breathing vapour. Prevent contact with eyes and skin.
Do not put water into container.
M.A.C. 1 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates the eyes severely.
The liquid burns the skin and the eyes.
If taken by mouth, there is severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

ACETYLENE DICHLORIDE—*see* 1,2-DICHLOROETHYLENE.

ACETYLENE TETRABROMIDE—*see* TETRABROMOETHANE.

ACETYLENE TETRACHLORIDE—*see* TETRACHLOROETHANE.

ACROLEIN (ACRALDEHYDE, ACRYLIC ALDEHYDE, PROPENAL). Colourless to yellow, volatile liquid with pungent, choking odour; somewhat soluble in water.

EXTREMELY HARMFUL, IRRITANT VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Prevent contact with eyes and skin.
M.A.C. 0·5 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system and may cause unconsciousness.
Short exposure may cause pain to the nose and eyes in addition to intense irritation.
Assumed to have extremely poisonous and irritant action if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention. Apply artificial respiration (p. 30) if breathing has stopped.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give an emetic (p. 29); obtain medical attention.

ACRYLONITRILE (VINYL CYANIDE). Colourless, volatile liquid with ethereal odour; miscible with water.

POISON
EXTREMELY HARMFUL, IRRITANT VAPOUR
HARMFUL BY SKIN ABSORPTION
HIGHLY INFLAMMABLE

Avoid breathing vapour. Prevent contact with skin and eyes.
Do not expose to flame or acids.
M.A.C. 20 p.p.m.

Acute Effects

Vapour may cause dizziness, nausea and unconsciousness.
The liquid may cause dermatitis and acute effects by absorption.
If swallowed, may cause acute poisoning.

Chronic Effects

Low concentrations of vapour inhaled over a long period may cause flushing of face, nausea, giddiness and jaundice.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; break capsule of amyl nitrite and give to inhale; in all but very mild cases, obtain medical attention. Apply artificial respiration (p. 30) if breathing has stopped.
Affected eyes: irrigate with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth with plenty of water and give emetic (p. 29); obtain medical attention.

ALLYL ALCOHOL (VINYL CARBINOL). Colourless liquid with pungent odour; miscible with water.

EXTREMELY HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION
HIGHLY INFLAMMABLE

Avoid breathing vapour. Prevent contact with skin and eyes.
M.A.C. 5 p.p.m.

Acute Effects

The vapour irritates eyes and respiratory tract severely.
The liquid irritates the eyes and skin.
Causes severe irritation of digestive organs and kidneys if swallowed.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.

Affected eyes: irrigate thoroughly with water; in severe cases and where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove contaminated clothing and wash before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ALLYL BROMIDE (3-BROMOPROPENE). Colourless liquid with an unpleasant smell; almost insoluble in water.

HARMFUL, IRRITANT VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with eyes and skin.

Acute Effects

The vapour irritates all parts of the respiratory system and may cause dizziness and headache.
The vapour and liquid irritate the eyes.
Assumed to be very irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ALLYL CHLORIDE (3-CHLOROPROPENE). Colourless, volatile liquid with unpleasant, pungent odour; immiscible with water.

EXTREMELY HARMFUL, IRRITANT VAPOUR
HARMFUL BY SKIN ABSORPTION
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 5 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system and inhalation may cause headache, dizziness and, in high concentrations, unconsciousness.
The vapour and liquid irritate the eyes.
Muscular pains may follow skin absorption.
Assumed to be very irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; obtain medical attention if exposure has been great.
Affected eyes: irrigate with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ALUMINIUM CHLORIDE ANHYDROUS. Yellow or off-white pieces, granules or powder; violently decomposed by water, with the formation of hydrogen chloride.

HARMFUL DUST
CORROSIVE—CAUSES BURNS

Avoid breathing dust. Prevent contact with eyes and skin.

Acute Effects

Inhalation of dust produces irritation or burns of the mucous membranes.
The material will cause painful eye burns.
When moisture is present on the skin, heat is produced on contact, resulting in thermal and acid burns.
If taken by mouth, the immediate local reaction causes severe burns.

First Aid

Dust inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases obtain medical attention.
Skin contact: drench with large quantity of water.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

AMMONIA AND SOLUTION (AMMONIUM HYDROXIDE). Colourless gas or liquid with a pungent suffocating odour.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS
HARMFUL IF TAKEN BY MOUTH

Avoid breathing vapour. Prevent contact with eyes and skin.
M.A.C. 100 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates the eyes and the liquid causes severe eye burns.
The liquid burns the skin.
If swallowed, the liquid causes severe internal damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water; give plenty of water followed by vinegar or 1 per cent acetic acid to drink; obtain medical attention.

AMMONIUM DICHROMATE—*see* CHROMATES AND DICHROMATES.

AMMONIUM FLUOROSILICATE—*see* FLUOROSILICIC ACID AND SALTS.

AMMONIUM HYDROGEN DIFLUORIDE—*see* FLUORIDES.

AMMONIUM OXALATE—*see* OXALIC ACID AND OXALATES.

AMMONIUM SULPHIDE SOLUTION. Yellow liquid with offensive odour.

HARMFUL VAPOUR EVOLVED, ESPECIALLY ON CONTACT WITH ACIDS

Avoid breathing vapour. Prevent contact with eyes and skin.

Acute Effects

Vapour inhaled in high concentration may cause unconsciousness. Lower concentrations cause headache, giddiness and loss of energy some time after exposure.
The liquid severely irritates the eyes.
The liquid causes severe internal damage if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; if splashing has occurred obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

AMMONIUM VANADATE—*see* VANADIUM COMPOUNDS.

AMYL NITRITE. Colourless or pale yellow, highly volatile liquid with pungent fruity odour; immiscible with water.

HARMFUL VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour.

Acute Effects

If inhaled may cause headache, flushing of face, weakness and collapse. If swallowed, similar effects may be expected.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: if splashing has occurred irrigate thoroughly with water and obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ANILINE. Colourless to brown liquid; immiscible with water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with eyes and skin.
M.A.C. 5 p.p.m.

Acute Effects

Inhalation of the vapour or absorption through the skin causes headache, drowsiness, cyanosis, mental confusion and, in severe cases, convulsions.
The liquid is dangerous to the eyes and the above effects are also experienced if it is swallowed.

Chronic Effects

Prolonged exposure to the vapour, or slight skin exposure over a period, affects the nervous system and the blood, causing fatigue, loss of appetite, headache and dizziness.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: when splashing has occurred irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ANILINE SALTS. The commoner aniline salts—the hydrochloride and sulphate—are soluble in water. They are colourless to greyish-brown in colour.

HARMFUL BY SKIN ABSORPTION

Avoid contact with eyes and skin.

Effects

The acute and chronic effects of aniline poisoning are described under ANILINE. Skin absorption does not occur so readily with the salts or their solutions as with aniline itself, but they are dangerous to the eyes, partly because of the acidity, and cause intense irritation.

If taken by mouth, the effects of aniline poisoning (headache, drowsiness, cyanosis) will be apparent.

First Aid

Affected eyes: irrigate with water until medical attention is obtained.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ANISIDINES (AMINO-ANISOLES). *o*-Anisidine is a pale yellow to orange liquid; immiscible with water. *p*-Anisidine is a pale yellow to brown solid; insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Effects

These are not recorded but are assumed to be similar to those of aniline poisoning, *i.e.* headache, drowsiness and cyanosis.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in the case of direct contact with liquid or solid obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ANTIMONY COMPOUNDS. Most antimony compounds are colourless crystals or powder; the pentachloride is a reddish, fuming liquid with an offensive smell. All antimony compounds must be considered to be poisonous when taken by mouth.

POISON

Acute Effects

Some compounds cause skin irritation and dermatitis.
If taken by mouth, antimony compounds may cause burning of the mouth and throat, choking, nausea and vomiting.
Stibine, which may be formed by the action of acidic reducing agents on antimony-containing materials, is an extremely poisonous gas, causing blood destruction and damage to liver and kidneys.

First Aid

Skin contact: wash with soap and water.
If swallowed: wash out mouth thoroughly with water and, if vomiting has not occurred, give emetic (p. 29); obtain medical attention.

ARSENIC AND COMPOUNDS. Most arsenic compounds are colourless powders or crystals—they include arsenites and arsenates of many metals; syrupy arsenic acid and arsenic trichloride are liquid. All must be considered to be extremely poisonous.

POISON
EXTREMELY HARMFUL BY SKIN ABSORPTION

Do not inhale dust or fume. Prevent contact with skin and eyes.
M.A.C. 0·25 mg/m.^{3}

Acute Effects

The inhalation of dust or fume irritates the mucous membranes and leads to arsenical poisoning.
Certain compounds, especially the trichloride and arsenic acid, irritate the eyes and skin and absorption causes poisoning.
If swallowed, arsenic compounds irritate the stomach severely and affect the heart, liver and kidneys; nervousness, thirst, vomiting, diarrhoea, cyanosis and collapse may be symptoms.
Arsine, which may be formed by the action of acidic reducing agents on arsenic-containing materials, is an extremely poisonous gas, causing blood destruction and damage to liver and kidneys.

Chronic Effects

The inhalation of small concentrations of dust or fume over a long period will cause poisoning. Skin contact over a long period may cause ulceration.

First Aid

Dust or fume inhaled: remove from exposure, rest and keep warm; obtain medical attention.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BARIUM COMPOUNDS. Practically all barium compounds are colourless crystals or powders. All barium compounds, except the sulphate, must be considered to be poisonous when taken by mouth.

POISON
HARMFUL BY SKIN ABSORPTION

Acute Effects

If ingested, barium compounds cause nausea, vomiting, stomach pains and diarrhoea.

First Aid

If swallowed: give two tablespoonfuls of magnesium sulphate (Epsom salts) in water and then an emetic (p. 29); rest and keep warm; obtain medical attention.

BENZAL CHLORIDE—*see* BENZYLIDENE CHLORIDE.

BENZENE (BENZOL; COAL NAPHTHA). Colourless, volatile liquid with characteristic odour; immiscible with water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION
HIGHLY INFLAMMABLE

Avoid inhalation of vapour. Avoid contact with skin and eyes.
M.A.C. 25 p.p.m.

Acute Effects

Inhalation of the vapour causes dizziness, headache and excitement; high concentrations may cause unconsciousness.
The vapour irritates the eyes and mucous membranes.
The liquid is absorbed through the skin and poisoning may result from this.
Assumed to be extremely poisonous if taken by mouth.

Chronic Effects

Repeated inhalation of low concentrations over a considerable period may cause severe, even fatal, blood disease.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and air contaminated clothing thoroughly before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BENZENE-DISULPHONIC AND **-SULPHONIC ACIDS**—see SULPHONIC ACIDS.

BENZENESULPHONYL CHLORIDE (BENZENE-SULPHON-CHLORIDE). Colourless to brown liquid; reacts with water to form benzene-sulphonic acid and hydrochloric acid.

CORROSIVE—CAUSES BURNS

Avoid contact with skin and eyes.

Acute Effects

Irritates the eyes severely and causes skin burns.
Causes severe internal irritation if taken by mouth.

First Aid

Affected eyes: when splashing has occurred, irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink, followed by milk of magnesia; obtain medical attention.

BENZIDINE AND SALTS. Benzidine is a colourless to grey powder, insoluble in water; it is normally supplied commercially as a paste with water. The salts are similar in appearance, the sulphate being insoluble in water, the hydrochloride soluble.

CARCINOGENIC
HARMFUL DUST
HARMFUL BY SKIN ABSORPTION

Do not breathe dust. Prevent contact with skin and eyes.

Acute Effects

The salts or their solutions irritate the eyes.

Chronic Effects

Prolonged exposure to the dust or prolonged absorption through the skin may cause bladder tumours.

Special Precautions

If an appreciable amount of the base or salt is being handled, rubber gloves, a dust mask and goggles should be worn.

First Aid

Affected eyes: irrigate thoroughly with water; if splashing with a solution of a salt has occurred, obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

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BENZONITRILE. Colourless liquid; sparingly soluble in water.

POISON
HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid inhalation of vapour. Avoid contact with skin and eyes.

Effects

No record has been found of instances of poisoning by this material, but its constitution is such that it must be assumed to be toxic by inhalation, skin and eye contact, and ingestion.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BENZOQUINONE (QUINONE). Yellow crystalline solid; slightly soluble in water.

HARMFUL BY SKIN ABSORPTION

Avoid contact with eyes and skin.

Effects

Causes skin irritation in some people. Assumed to be toxic if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BENZOTRICHLORIDE ($\alpha\alpha\alpha$-TRICHLOROTOLUENE). Colourless to yellow, fuming liquid; immiscible with water.

IRRITANT VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with eyes and skin.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour and liquid irritate the eyes and skin.
If taken by mouth, internal irritation and damage must be assumed.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BENZOYL CHLORIDE. Colourless, fuming liquid with pungent smell; reacts with water forming benzoic acid and hydrochloric acid.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Avoid contact with eyes and skin.

Acute Effects

The vapour irritates the respiratory system.
The vapour irritates and the liquid burns the eyes severely.
The liquid is very irritating to the skin and can cause burns.
If taken by mouth there is immediate irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water, remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give water to drink followed by milk of magnesia; obtain medical attention.

BENZYLAMINE. Colourless liquid; miscible with water.

CORROSIVE—CAUSES BURNS

Avoid contact with skin and eyes.

Effects

These have not been recorded to any extent, but it has been found that benzylamine causes skin burns; by inference it must be assumed to damage the eyes and cause internal irritation and damage if taken by mouth.

First Aid

Affected eyes: if splashing has occurred, irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

BENZYL BROMIDE (α-BROMOTOLUENE). Colourless to pale yellow liquid; immiscible with water.

HARMFUL, EXTREMELY IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with skin and eyes.

Acute Effects

The vapour irritates the respiratory system.
Low vapour concentrations cause lachrymation and severe irritation to the eyes.
The vapour irritates the skin and the liquid causes burns.
Can be assumed to cause severe internal irritation and damage if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BENZYL CHLORIDE (α-CHLOROTOLUENE). Colourless to brown-yellow liquid with acrid smell; immiscible with water.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS
INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 1 p.p.m.

Acute Effects

The vapour irritates the respiratory system.
Low vapour concentrations cause lachrymation and severe irritation to the eyes.
The vapour irritates the skin and the liquid causes burns.
Can be assumed to cause severe internal irritation and damage if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BENZYL CYANIDE (PHENYLACETONITRILE). Colourless to yellow liquid; insoluble in water.

POISON
HARMFUL VAPOUR

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

Inhalation of the vapour may cause pallor, faintness, headache and possibly vomiting.
The liquid irritates the eyes and may irritate the skin.
If taken by mouth, internal irritation and poisoning must be assumed.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BENZYLIDENE CHLORIDE (BENZAL CHLORIDE). Colourless liquid; immiscible with water.

IRRITANT VAPOUR

Avoid breathing vapour. Avoid contact with eyes and skin.

Acute Effects

The vapour irritates the respiratory system.
The vapour and liquid irritate the eyes and may cause conjunctivitis.
The liquid may irritate the skin.
If taken by mouth, internal irritation and damage must be assumed.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BERYLLIUM COMPOUNDS. White powder or crystals.

EXTREMELY HARMFUL DUST
HARMFUL BY SKIN ABSORPTION

Avoid inhaling dust. Prevent contact with eyes and skin.

M.A.C. 2 $\mu g/m^3$ (8 hr working day) or 25 $\mu g/m^3$ (30 min exposure).

Effects

Particles penetrating the skin through wounds and abrasions may cause local damage difficult to heal.
Symptoms of poisoning, indicated by respiratory troubles or cyanosis, may develop within a week or after a latent period of even several years.

First Aid

Dust inhaled: remove from exposure, rest and keep warm; obtain medical attention.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water and remove any penetrating particles.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BORON HALIDES. Boron trichloride is a colourless, low boiling liquid which reacts with water forming hydrogen chloride. Boron trifluoride is a colourless gas, soluble in water.

EXTREMELY HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with eyes and skin.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour causes irritation of the eyes.
The liquid burns the skin and eyes.
If taken by mouth, there would be severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water; give large quantity of water to drink followed by milk of magnesia; obtain medical attention.

BROMINE. Dark reddish-brown fuming liquid; slightly soluble in water.

EXTREMELY IRRITANT VAPOUR
EXTREMELY CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with eyes and skin.
M.A.C. 1 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour severely irritates the eyes and mucous membranes.
The liquid burns the skin and eyes.
If taken by mouth, severe local burns, internal irritation and damage would result.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and then bathe with a dilute solution of ammonia or sodium thiosulphate in water; obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give large quantity of water to drink; obtain medical attention.

BROMOACETIC ACID. Colourless to pale brown solid; soluble in water.

EXTREMELY CORROSIVE—CAUSES SEVERE BURNS

Prevent contact with skin and eyes.

Acute Effects

Contact of the solid or solution with the eyes causes severe burns.
The effect on the skin is not immediate and blisters may not appear for 12 hours or more after contact.
Can be assumed to cause severe internal irritation and damage if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use. Blisters must receive medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink, followed by milk of magnesia; obtain medical attention.

α-BROMOACETOPHENONE—*see* PHENACYL BROMIDE.

BROMOETHANE (ETHYL BROMIDE). Colourless, volatile liquid with ethereal odour; sparingly soluble in water.

HARMFUL, IRRITANT VAPOUR

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 200 p.p.m.

Chronic Effects

Can produce damage to the nervous system.

Acute Effects

The vapour irritates the respiratory system; it has anaesthetic and narcotic effects.
The liquid irritates the eyes.
The liquid is poisonous if taken by mouth, causing damage to the kidneys.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: if splashing has occurred, irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

BROMOMETHANE (METHYL BROMIDE). Colourless, volatile liquid (b.p. 4°C) or gas with faint chloroform-like odour; liquid forms a crystalline hydrate with cold water and penetrates rubber.

EXTREMELY HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION
CAUSES BURNS

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 20 p.p.m.

Acute Effects

Short exposures to high concentrations of vapour cause headache, dizziness, nausea, vomiting and weakness; this may be followed by mental excitement, convulsions and even acute mania.
The longer inhalation of lower concentrations may lead to bronchitis and pneumonia.
Both the vapour and liquid cause severe damage to the eyes.
The liquid burns the skin, blisters appearing several hours after contact; itching and reddening of the skin may precede this.
Assumed to be very poisonous if taken by the mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water and wash thoroughly with soap and water; blisters must receive medical attention; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

α-BROMOTOLUENE—*see* BENZYL BROMIDE.

BUTYLAMINES. The butylamines (n-butylamine, iso-butylamine, sec-butylamine, di-n-butylamine, di-iso-butylamine, di-sec-butylamine and tri-n-butylamine) are colourless liquids with an ammoniacal odour; miscible with water.

HARMFUL VAPOUR
MAY CAUSE BURNS
INFLAMMABLE OR HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 5 p.p.m.

Acute Effects

The vapour irritates the respiratory system.
The vapour irritates and the liquid burns the eyes.
The liquid may cause skin and eye burns.
Assumed to be very irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

CADMIUM COMPOUNDS. Chloride, nitrate and sulphate soluble in water; oxide and carbonate insoluble.

HARMFUL DUST
HARMFUL IF TAKEN BY MOUTH

Avoid inhaling dust.

Acute Effects

The inhalation of dust (usually the metal or oxide) irritates the lungs.
The compounds cause increased salivation, choking, vomiting, stomach pains and diarrhoea if taken by mouth.

Chronic Effects

Prolonged exposure to dust may cause damage to the lungs and kidneys and discoloration of teeth.

First Aid

Dust inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CALCIUM CYANAMIDE. Grey-black granules or powder; decomposed by water.

HARMFUL, IRRITANT DUST

Avoid inhaling dust. Prevent contact with eyes and skin.

Acute Effects

Inhalation of dust can cause severe irritation of the mucous membranes.
The material irritates the eyes and can cause conjunctivitis.
The material will burn the skin.
If taken by mouth, there is severe internal irritation and damage which may result in death.

First Aid

Dust inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water and give cyanide antidote (p. 34); obtain medical attention.

CALCIUM HYDROGEN DIFLUORIDE AND TRIFLUORIDE—*see* FLUORIDES.

CALCIUM OXALATE—*see* OXALATES.

CARBOLIC ACID—*see* PHENOL.

CARBON DISULPHIDE (CARBON BISULPHIDE). Colourless to yellow liquid, with unpleasant odour; immiscible with water.

EXTREMELY HARMFUL VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour.
M.A.C. 20 p.p.m.

Acute Effects

High concentrations when inhaled produce narcotic effects and may result in unconsciousness.
The liquid and vapour irritate the eyes.
The liquid is poisonous if taken by mouth.

Chronic Effects

Repeated inhalation of the vapour over a period may cause severe damage to the nervous system, including failure of vision, mental disturbance and paralysis.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention. Apply artificial respiration (p. 30) if breathing has stopped.

Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CARBON MONOXIDE (COAL GAS CONSTITUENT). Colourless, odourless gas; only slightly soluble in water.

EXTREMELY HARMFUL GAS

Avoid breathing gas.
M.A.C. 100 p.p.m.

Acute Effects

Causes unconsciousness due to anoxia resulting from the combination of carbon monoxide with haemoglobin.

Gas in lower concentrations causes headache, throbbing of temples, nausea, followed possibly by collapse.

Chronic Effects

Headache, nausea and weakness.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; if subject unconscious obtain medical attention. Apply artificial respiration (p. 30) if breathing has stopped.

CARBON TETRACHLORIDE (TETRACHLOROMETHANE). Heavy, colourless liquid with a characteristic odour; immiscible with water. When used for extinguishing fires, phosgene (*q.v.*), which is very poisonous, is liable to be formed.

HARMFUL VAPOUR

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 25 p.p.m.

Acute Effects

Inhalation of high concentrations of vapour can cause headache, mental confusion, depression, fatigue, loss of appetite, nausea, vomiting and coma, these symptoms sometimes taking many hours to appear.

The vapour and liquid irritate the eyes.

It causes internal irritation, nausea and vomiting if taken by mouth; there is damage to the liver, kidneys, heart and nervous system and small doses have caused death.

Chronic Effects

Prolonged inhalation of low concentrations may cause headache, nausea, stupor, vomiting, bronchitis and jaundice. Dermatitis may follow repeated contact with the liquid.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention. Apply artificial respiration (p. 30) if breathing has stopped.
Affected eyes: irrigate thoroughly with water; where splashing has occurred obtain medical attention.
Skin contact: drench with water and wash thoroughly with soap and water; remove and air contaminated clothing thoroughly before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CARBONYL CHLORIDE—*see* PHOSGENE.

CATECHOL (PYROCATECHOL, *o*-DIHYDROXYBENZENE). Colourless crystalline powder; soluble in water.

HARMFUL BY SKIN ABSORPTION
CORROSIVE—CAUSES BURNS

Avoid contact with skin and eyes.

Acute Effects

Irritates the eyes severely, causing burns.
Irritates the skin and causes poisoning by absorption.
Assumed to be irritant and poisonous if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give water to drink followed by two tablespoonfuls of magnesium sulphate (Epsom salts) in water.

CAUSTIC POTASH—*see* POTASSIUM HYDROXIDE.

CAUSTIC SODA—*see* SODIUM HYDROXIDE.

CELLOSOLVE—*see* 2-ETHOXYETHANOL.

CHLORAL HYDRATE (TRICHLOROACETIC ALDEHYDE). Colourless crystals with acrid odour and bitter taste; soluble in water.

HARMFUL IF TAKEN BY MOUTH

Avoid contact with skin and eyes.

Acute Effects

Irritates the skin and eyes.
If taken by mouth it may cause nausea, vomiting, coldness of extremities and unconsciousness.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); rest and keep warm; obtain medical attention.

CHLORINE. Greenish-yellow gas with irritating odour; soluble in water.

EXTREMELY IRRITANT HARMFUL GAS

Avoid breathing gas.
M.A.C. 1 p.p.m.

Acute Effects

The gas causes severe lung irritation and damage.
The gas irritates the eyes and can cause conjunctivitis.
In high concentrations the gas irritates the skin.

First Aid

Gas inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases obtain medical attention.
Skin contact: drench thoroughly with water.

CHLOROACETIC ACID. Colourless to pale brown crystals; soluble in water.

EXTREMELY CORROSIVE—CAUSES SEVERE BURNS

Prevent contact with skin and eyes.

Acute Effects

The solid or its solutions severely irritate or burn the eyes.
The solid or its solutions produce severe skin burns which may only be apparent several hours after contact.
Assumed to cause severe internal irritation and damage if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use; blisters must receive medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

α-CHLOROACETOPHENONE—*see* PHENACYL CHLORIDE.

CHLOROACETYL CHLORIDE. Colourless to pale yellow liquid; reacts with water.

EXTREMELY IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with skin and eyes.

Acute Effects

The vapour irritates severely all parts of the respiratory system.
The vapour irritates and the liquid burns the eyes.
The vapour irritates the skin and the liquid may produce blisters several hours after contact.
Assumed to cause severe internal irritation and damage if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use; blisters must receive medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

CHLOROANILINES. The *o*- and *m*-chloroanilines are yellow to brown liquids; *p*-chloroaniline is an almost colourless crystalline solid or powder. All are insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The inhalation of vapour and absorption through the skin may cause cyanosis, and damage to the liver and kidneys.
Assumed that similar poisoning will result from ingestion.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes (direct contact): irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CHLOROBENZENE (MONOCHLOROBENZENE). Clear colourless liquid with a faint, not unpleasant odour; immiscible with water.

HARMFUL VAPOUR
INFLAMMABLE

Avoid breathing vapour.
M.A.C. 75 p.p.m.

Acute Effects

The vapour may cause drowsiness and unconsciousness.
The liquid may cause stupor and unconsciousness after a few hours if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: where splashing has occurred irrigate thoroughly with water; obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

1-CHLORO-2,4-DINITROBENZENE (2,4-DINITROCHLOROBENZENE). Pale yellow crystals; insoluble in water.

HARMFUL DUST AND VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing dust and vapour. Avoid contact with skin and eyes.

Effects

The dust, or vapour from the molten compound, irritates the respiratory system.
Contact with the skin may cause dermatitis.
Cyanosis and liver injury may follow inhalation or skin absorption.
Assumed to be poisonous if taken by mouth.

First Aid

Dust or vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove contaminated clothing and wash before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

1-CHLORO-2,3-EPOXYPROPANE (EPICHLORHYDRIN). Colourless liquid with irritating chloroform-like odour; immiscible with water.

HARMFUL, IRRITANT VAPOUR
HARMFUL BY SKIN ABSORPTION
INFLAMMABLE

Acute Effects

The vapour irritates the respiratory system.
The vapour and liquid irritate the eyes.
Assumed to be poisonous by skin absorption and ingestion.

Chronic Effects

Prolonged exposure to low concentrations of vapour may cause conjunctivitis, chronic weariness and stomach upset.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, or when splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

2-CHLOROETHANOL (ETHYLENE CHLOROHYDRIN; CHLOROETHYL ALCOHOL). Colourless liquid with a faint alcoholic odour; miscible with water.

EXTREMELY HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION
INFLAMMABLE

Avoid breathing vapour. Prevent contact with skin and eyes.
M.A.C. 5 p.p.m.

Acute Effects

The vapour causes nausea, headaches, vomiting, stupefaction and unconsciousness. It irritates the mucous membranes.
The liquid is rapidly absorbed by the skin, producing similar effects to inhalation.
Assumed to be extremely poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; obtain medical attention.
Affected eyes: when splashing has occurred, irrigate thoroughly with water; obtain medical attention.

Skin contact: drench with water and wash with soap and water; in severe cases obtain medical attention; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CHLOROFLUORO-HYDROCARBONS. A variety of these compounds are used as refrigerants; they are generally colourless gases or liquids; insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour has narcotic and irritant effects, which may also be caused by skin absorption and ingestion.

Chronic Effects

May damage liver and cause jaundice.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CHLOROFORM (TRICHLOROMETHANE). Colourless volatile liquid with a characteristic odour; immiscible with water.

HARMFUL VAPOUR

Avoid breathing vapour. Avoid contact with eyes.
M.A.C. 100 p.p.m.

Acute Effects

The vapour has anaesthetic properties, causing drowsiness, giddiness, headache, nausea, vomiting and unconsciousness.
The vapour and liquid irritate the eyes causing conjunctivitis.
The liquid is poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention. Apply artificial respiration (p. 30) if breathing has stopped.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CHLORO-NITROANILINES. 2-Chloro-4-nitro- and 4-chloro-2-nitro-anilines are yellow to brownish-yellow powders or crystals; insoluble in water.

HARMFUL BY SKIN ABSORPTION

Avoid contact with skin and eyes.

Acute Effects

Absorption through the skin may cause dermatitis, cyanosis and damage to the liver and kidneys.
Assumed that similar poisoning will result from ingestion.

First Aid

Affected eyes (direct contact): irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CHLORONITROBENZENES. *o*-, *m*- and *p*-Chloronitrobenzenes are yellow solids of low melting point; insoluble in water.

HARMFUL DUST AND VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing dust and vapour. Avoid contact with skin and eyes.

Acute Effects

The dust or vapour from the molten compounds irritate the respiratory system. Contact with the skin may cause dermatitis.
Cyanosis and liver injury may follow inhalation or skin absorption.
Assumed to be poisonous if taken by mouth.

First Aid

Dust or vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CHLOROPHENOLS. *o*-Chlorophenol is a pale brown to brown liquid; *p*-chlorophenol is a colourless to pale brown crystalline solid with a phenolic (carbolic) odour. Both compounds are sparingly soluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION
CORROSIVE—CAUSE BURNS

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour when inhaled irritates the respiratory system.
In contact with the eyes they cause intense irritation or burning.
They irritate and may burn the skin and must be assumed to be very poisonous and irritant if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water and in the case of direct contact, obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by two tablespoonfuls of magnesium sulphur (Epsom salts) in water; obtain medical attention.

CHLOROPICRIN (TRICHLORONITROMETHANE). Colourless liquid with intense penetrating odour; almost insoluble in water.

EXTREMELY HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Do not breath vapour. Avoid contact with skin and eyes.
M.A.C. 1 p.p.m.

Acute Effects

The vapour irritates the respiratory system severely, leading in severe cases to bronchitis and recurrent asthmatic attacks through lung damage; it causes nausea and vomiting.
The vapour irritates the eyes severely, causing intense lachrymation.
The vapour and liquid irritate the skin.
If swallowed, the liquid causes vomiting and diarrhoea.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; if vomiting has not occurred, give emetic (p. 29); obtain medical attention.

CHLOROSULPHONIC ACID. Colourless to brown fuming liquid; decomposing with explosive violence when mixed with water.

IRRITANT VAPOUR
EXTREMELY CORROSIVE—CAUSES SEVERE BURNS

Avoid breathing vapour. Prevent contact with eyes and skin.
M.A.C. 10 p.p.m.

Acute Effects

The fumes are very irritant to the lungs and mucous membranes.
The fumes irritate the eyes severely.
The liquid burns the skin and eyes.
If taken by mouth there would be severe local and internal corrosive effects.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench thoroughly with water and obtain medical attention.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

α-CHLOROTOLUENE—*see* BENZYL CHLORIDE.

CHROMATES AND DICHROMATES. Generally yellow or orange-red crystals or powder; soluble in water.

HARMFUL DUST
MAY CAUSE SKIN ULCERATION

Avoid inhaling dust. Avoid contact with eyes and skin.

Acute Effects

The dust irritates the respiratory tract.
The dust irritates the eyes severely.
If taken by mouth there is irritation and internal damage.

Chronic Effects

Frequent exposure of skin to dust can cause ulceration.
Long-continued absorption can cause liver and kidney disease and even cancer.

First Aid

Dust inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench thoroughly with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CHROMIC ACID—*see* CHROMIUM TRIOXIDE.

CHROMIUM TRIOXIDE (CHROMIC ACID). Dark red crystalline masses or flakes; soluble in water.

HARMFUL DUST
CORROSIVE—MAY CAUSE SKIN ULCERATION

Avoid inhaling dust. Prevent contact with eyes and skin.
M.A.C. 0·1 mg/m³.

Acute Effects

The dust irritates all parts of the respiratory system.
The solid and its solutions cause severe eye burns.
The solid and its solutions burn the skin.
If taken by mouth there would be severe internal irritation and damage.

Chronic Effects

Frequent exposure of skin to the material may result in ulceration.

First Aid

Dust inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench thoroughly with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

CHROMYL CHLORIDE. Red fuming liquid.

HARMFUL VAPOUR
CORROSIVE—CAUSES BURNS
MAY CAUSE SKIN ULCERATION

Avoid breathing vapour. Prevent contact with eyes and skin.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates the eyes severely.
The liquid burns the skin and eyes.
If taken by mouth there would be severe local and internal irritation and damage.

Chronic Effects

Frequent exposure of skin to the material may result in ulceration.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water and obtain medical attention.

Skin contact: drench thoroughly with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

COAL GAS—*see* CARBON MONOXIDE.

COPPER COMPOUNDS. Blue or greenish-blue crystals or powder.

HARMFUL DUST

Avoid inhaling dust. Prevent contact with eyes and skin.

Acute Effects

The dust irritates the mucous membranes.
The dust and solutions of salts irritate the eyes.
Ingestion may cause violent vomiting and diarrhoea with intense abdominal pain and collapse.

First Aid

Dust inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases obtain medical attention.
If swallowed: wash out mouth with plenty of water and, if vomiting has not occurred, give emetic (p. 29); obtain medical attention.

CRESOLS (CRESYLIC ACID). *o*-Cresol—a colourless to pale brown crystals. *m*-Cresol—a colourless to yellow liquid. *p*-Cresol—colourless to pink crystals. Cresylic acid (mixed isomers)—colourless to brown liquid. All cresols have a phenolic (carbolic) odour and are sparingly soluble in water.

HARMFUL BY SKIN ABSORPTION
CORROSIVE—CAUSE BURNS
HARMFUL IF TAKEN BY MOUTH

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour from heated cresols is irritant to the respiratory system.
Cresols burn the eyes severely and irritate or burn the skin.
Considerable absorption through the skin may give effects similar to those caused by ingestion, namely headache, dizziness, nausea, vomiting, stomach pain, exhaustion and possibly coma.

Chronic Effects

Repeated inhalation or absorption of small amounts may cause damage to liver or kidneys.
Repeated contact with skin may cause dermatitis.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water and, in the case of direct contact, obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by two tablespoonfuls of magnesium sulphate (Epsom salts) in water; obtain medical attention.

CRESYLIC ACID—*see* CRESOL.

CROTONALDEHYDE. Colourless liquid with a pungent, suffocating odour; immiscible with water.

EXTREMELY HARMFUL VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour irritates the respiratory system.
The vapour and liquid irritate the eyes severely, causing lachrymation and burns.
The liquid irritates the skin.
Assumed to be irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

CYANIDES (POTASSIUM CYANIDE AND SODIUM CYANIDE). Colourless crystals or powders soluble in water. React with acids to form hydrocyanic acid gas.

POISON
LIBERATE POISONOUS GAS ON CONTACT WITH ACIDS
CORROSIVE—CAUSE BURNS
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Prevent contact with eyes and skin.

Acute Effects

Inhalation of dust or vapour may cause giddiness, dizziness, rapid heart action, shortness of breath, followed by unconsciousness and death.

The vapour and dust irritate the eyes severely.

The solids or their solutions are absorbed through the skin and can cause burns because of hydrolysis to caustic alkalis.

Extremely poisonous if taken by mouth—respiration at first rapid but soon becomes slow and gasping, resulting in unconsciousness and death.

First Aid

Prompt treatment is of the utmost importance; in all cases obtain medical attention.

Dust or vapour inhaled: remove from exposure, rest and keep warm; if breathing break capsule of amyl nitrite and give to inhale for 15–30 seconds; repeat every 2–3 minutes. Apply artificial respiration (p. 30) if breathing has stopped.

Affected eyes: irrigate thoroughly with water.

Skin contact: drench with water; remove and wash contaminated clothing before re-use.

If swallowed: if conscious give cyanide antidote (see p. 34); if breathing, break capsule of amyl nitrite and give to inhale for 15–30 seconds; repeat every 2–3 minutes. Apply artificial respiration (p. 30) if breathing has stopped.

CYCLOHEXYLAMINE (HEXAHYDROANILINE). Colourless liquid with an ammoniacal, fishy odour. Miscible with water.

HARMFUL VAPOUR
CORROSIVE—CAUSES BURNS
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour may cause irritation of the eyes and respiratory system, causing difficulty in breathing.

The liquid can burn the eyes and skin; skin absorption may cause nausea and vomiting.

Assumed to be poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.

Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.

Skin contact: drench with water; remove contaminated clothing and wash before re-use.

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

DIAMINOETHANE (ETHYLENEDIAMINE). Clear, colourless liquid with ammoniacal odour; miscible with water.

IRRITANT VAPOUR
HARMFUL BY SKIN ABSORPTION
INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 10 p.p.m.

Acute Effects

The vapour irritates the respiratory system.
The liquid and vapour cause irritation of skin and eyes.
If swallowed, may cause digestive disturbance and possibly damage to the kidneys.

Chronic Effects

Repeated inhalation of vapour or skin contact may cause sensitization of skin or respiratory system.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

o-DIANISIDINE AND ITS DIHYDROCHLORIDE. *o*-Dianisidine is a colourless to grey-mauve powder; insoluble in water. Its dihydrochloride is a colourless to grey powder, sparingly soluble in water.

IRRITANT DUST
HARMFUL BY SKIN ABSORPTION

Do not breathe dust. Prevent contact with skin and eyes.

Acute Effects

The dust irritates the nose severely, causing sneezing.
Solutions of the dihydrochloride irritate the eyes.
The effects of ingestion are not recorded.

Chronic Effects

There is evidence that *o*-dianisidine, through continued absorption, can cause cancer of the bladder.

First Aid

Dust inhaled: wash out nose and mouth thoroughly with water.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

DIAZOMETHANE. A yellow gas generally employed for organic synthesis in chloroformic or ethereal solution.

EXTREMELY HARMFUL IRRITANT VAPOUR

Prevent inhalation of vapour and contact with skin and eyes.

Acute Effects

Irritates the respiratory system, eyes and skin.
Inhalation may result in chest discomfort, headache, weakness and, in severe cases, collapse.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; if subject unconscious, obtain medical attention; apply artificial respiration (p. 30) if breathing has stopped.
Affected eyes: irrigate thoroughly with water.

1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE). Colourless liquid with sweetish chloroform-like odour; immiscible with water.

IRRITANT VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 25 p.p.m.

Acute Effects

The vapour irritates the respiratory system and may have narcotic action.
The vapour and liquid irritate the eyes.
The liquid irritates the skin.
Assumed to be poisonous by skin absorption and ingestion.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

o-DICHLOROBENZENE. Colourless liquid with a pleasant aromatic odour; insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION
INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 50 p.p.m.

Acute Effects

Inhalation of vapour may cause drowsiness and irritation of the nose.
The liquid irritates the eyes severely.
The liquid irritates the skin and may cause dermatitis.
Poisonous when taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

1,2-DICHLOROETHANE (ETHYLENE DICHLORIDE). Colourless liquid with a chloroform-like odour; immiscible with water.

HARMFUL VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 100 p.p.m.

Acute Effects

In high concentrations, the vapour irritates the eyes and respiratory system; it may also cause drowsiness, headache, vomiting and mental confusion.
The liquid may cause serious damage to the eyes.
Assumed to be poisonous if taken by mouth.

Chronic Effects

Continued exposure to low concentrations may result in dizziness, nausea and abdominal pain, and there may be damage to the eyes and liver.
Dermatitis may follow repeated contact with the skin.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention. Apply artificial respiration (p. 30) if breathing has stopped.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurrred, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

1,2-DICHLOROETHYLENE (ACETYLENE DICHLORIDE). Colourless liquid with a slight chloroform-like odour; immiscible with water.

HARMFUL VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour.
M.A.C. 200 p.p.m.

Acute Effects

The vapour irritates the eyes and mucous membranes; in high concentrations it may cause drowsiness and unconsciousness.
Assumed to be poisonous if taken by mouth.

Chronic Effects

Continued exposure to low concentrations of vapour may cause drowsiness and digestive disturbance.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

DI-(2-CHLOROETHYL) ETHER ($\beta\beta$-DICHLOROETHYL ETHER). Colourless liquid with pungent odour; practically insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 15 p.p.m.

Acute Effects

The vapour irritates the respiratory system and high concentrations may result in lung damage after a latent period of some hours.
The vapour and liquid irritate the eyes.
Assumed to be poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

DICHLOROMETHANE (METHYLENE CHLORIDE). Colourless volatile liquid with chloroform-like odour; immiscible with water.

HARMFUL VAPOUR

Avoid breathing vapour. Avoid contact with eyes.
M.A.C. 500 p.p.m.

Acute Effects

Inhalation of vapour may cause headache and nausea; high concentrations may result in cyanosis and unconsciousness.
The liquid irritates the eyes.
Assumed to be poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

2,4-DICHLOROPHENOL. Colourless crystals; almost insoluble in water.

HARMFUL BY SKIN ABSORPTION
CORROSIVE—CAUSES BURNS

Avoid contact with skin and eyes.

Acute Effects

Causes severe irritation or burns in contact with the eyes and skin.
Assumed to be very poisonous and irritant if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by two tablespoonfuls of magnesium sulphate (Epsom salts) in water; obtain medical attention.

αα-DICHLOROTOLUENE—*see* BENZYLIDENE CHLORIDE.

***N*:*N*-DIETHYLANILINE.** Colourless to brown liquid; sparingly soluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

Excessive breathing of the vapour or absorption of the liquid through the skin can cause headache, drowsiness, cyanosis, mental confusion and, in severe cases, convulsions.

The liquid is dangerous to the eyes and the above effects can also be experienced if it is swallowed.

Chronic Effects

Continued exposure to the vapour or slight skin exposure to the liquid over a period may affect the nervous system and the blood, causing fatigue, loss of appetite, headache and dizziness.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.

Affected eyes: where splashing has occurred, irrigate thoroughly with water and obtain medical attention.

Skin contact: drench with water and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

DIETHYLENE DIOXIDE (OXIDE)—*see* DIOXAN.

DIETHYL ETHER (ETHER; ETHYL ETHER; SULPHURIC ETHER).

Colourless, highly volatile liquid with characteristic odour; immiscible with water.

HARMFUL VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour.
M.A.C. 400 p.p.m.

Acute Effects

Inhalation of vapour may cause drowsiness, dizziness, mental confusion, faintness and, in high concentrations, unconsciousness.

Ingestion may also produce these effects.

Chronic Effects

Continued inhalation of low concentrations may cause loss of appetite, dizziness, fatigue and nausea. Repeated inhalation or swallowing may lead to 'ether habit', with symptoms resembling chronic alcoholism.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.

Affected eyes: irrigate thoroughly with water; where splashing has occurred, obtain medical attention.

If swallowed: wash out mouth with water and give emetic (p. 29); obtain medical attention.

DIETHYL SULPHATE (ETHYL SULPHATE). Colourless liquid with faint ethereal odour; insoluble in water.

EXTREMELY HARMFUL VAPOUR

Avoid breathing vapour. Avoid contact with skin and eyes.

Effects

Its effect on humans has not been recorded, but authorities consider that animal experiments justify its classification as a dangerous chemical.

It is assumed to be poisonous or irritant by inhalation, eye and skin contact and ingestion.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.

Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.

Skin contact: drench with water and wash thoroughly with soap and water; obtain medical attention.

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

DIMETHYLAMINE AND SOLUTIONS. Colourless gas at ordinary temperatures (b.p. 7°C); readily soluble in water. Commonly available in aqueous and ethanolic solution.

IRRITANT VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour irritates the mucous membranes and respiratory system; in high concentrations may affect the nervous system.

The vapour and solutions irritate the eyes.

The solutions may irritate the skin.

Assumed to be poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.

Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.

Skin contact: drench with water; remove and wash contaminated clothing before re-use.

If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

***NN*-DIMETHYLANILINE.** Colourless to brown liquid; sparingly soluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

Excessive breathing of the vapour or absorption of the liquid through the skin can cause headache, drowsiness, cyanosis, mental confusion and, in severe cases, convulsions.

The liquid is dangerous to the eyes and the above effects can also be experienced if it is swallowed.

Chronic Effects

Continued exposure to the vapour or slight skin exposure to the liquid over a period may affect the nervous system and the blood causing fatigue, loss of appetite, headache and dizziness.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.

Affected eyes: where splashing has occurred, irrigate thoroughly with water and obtain medical attention.

Skin contact: drench with water and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

***NN*-DIMETHYL-*p*-NITROSOANILINE** (NITROSODIMETHYLANILINE). Green powder; insoluble in water.

IRRITANT DUST

Avoid breathing dust. Avoid contact with skin and eyes.

Acute Effects

The dust irritates the respiratory system.

The dust irritates the eyes and skin and may cause dermatitis.

Assumed to be irritant and poisonous if taken by mouth.

First Aid

Dust inhaled: remove from exposure; rest and keep warm.

Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.

Skin contact: drench with water and wash with soap and water.

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

DIMETHYL SULPHATE (METHYL SULPHATE). Colourless, odourless liquid; somewhat soluble in water.

EXTREMELY HARMFUL VAPOUR
CORROSIVE—CAUSES BURNS
HARMFUL BY SKIN ABSORPTION

Do not breath vapour. Prevent contact with skin and eyes.
M.A.C. 1 p.p.m.

Acute Effects

Vapour causes severe irritation of respiratory system, with possible severe lung injury after a latent period.
Vapour and liquid irritate or burn the eyes severely after a latent period, resulting in temporary or permanent dimming of vision.
The vapour or liquid may blister the skin and skin absorption may result in severe poisoning after a latent period.
Extremely poisonous and irritant if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; obtain medical attention.
Affected eyes: irrigate very thoroughly with water; obtain medical attention.
Skin contact: drench very thoroughly with water; remove and wash contaminated clothing before re-use; obtain medical attention.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

2,4-DINITROANILINE. Yellow granules or powder; insoluble in water.

HARMFUL BY SKIN ABSORPTION

Avoid contact with skin and eyes.

Effects

These have not been recorded, but it can be assumed that skin absorption is liable to cause dermatitis and cyanosis, and that the eyes would be damaged by contact. It must also be assumed to be poisonous if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

***m*-DINITROBENZENE.** Colourless to yellow crystals; insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour may cause headache, vertigo and vomiting; in severe cases this may be followed by exhaustion, cyanosis, drowsiness and unconsciousness.
Contact will damage the eyes, and skin absorption may lead to the above symptoms.
Assumed to be poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove contaminated clothing and wash before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

2,4-DINITROCHLOROBENZENE—*see* 1-CHLORO-2,4-DINITRO-BENZENE.

DINITRO-*o*-CRESOL. Yellow crystals or powder; almost insoluble in water.

HARMFUL DUST
HARMFUL BY SKIN ABSORPTION

Avoid breathing dust. Avoid contact with skin and eyes.
M.A.C. 0·2 mg/m³.

Acute Effects

The inhalation of dust may cause profuse sweating, fever, shortness of breath and yellow coloration of skin of hands and feet.
Similar symptoms may follow ingestion and absorption through the skin. Skin contact may cause dermatitis.

First Aid

Dust inhaled: remove from exposure; rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove contaminated clothing and wash before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

DINITROPHENOLS. Yellow crystals or powder; sparingly soluble in water.

POISON
HARMFUL DUST
HARMFUL BY SKIN ABSORPTION

Avoid breathing dust. Avoid contact with skin and eyes.

Acute Effects

The inhalation of dust may cause profuse sweating, fever, shortness of breath and yellow coloration of skin of hands and feet.
Similar symptoms may follow ingestion and absorption through the skin. Skin contact may cause dermatitis.

First Aid

Dust inhaled: remove from exposure; rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove contaminated clothing and wash before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by two tablespoonfuls of magnesium sulphate (Epsom salts) in water; obtain medical attention.

2,4-DINITROTOLUENE. Yellow crystals; insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid contact with skin and eyes.

Acute Effects

The vapour and crystals irritate the eyes.
Contact with the skin may cause dermatitis.
Assumed to be poisonous if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench with water and wash with soap and water.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

DIOXAN (DIETHYLENE DIOXIDE; DIETHYLENE OXIDE; DIOXANE). Colourless, almost odourless, liquid; miscible with water.

IRRITANT VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour.
M.A.C. 100 p.p.m.

Acute Effects

The vapour irritates nose and eyes somewhat and this may be followed by headache and drowsiness. High concentrations may also cause nausea and vomiting, while injury to the kidney and liver are possible.

Highly poisonous and shows some of the above effects when taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.

Affected eyes: irrigate thoroughly with water; where splashing has occurred, obtain medical attention.

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

EPICHLOROHYDRIN—see 1-CHLORO-2,3-EPOXYPROPANE.

ETHANEDIOL (ETHYLENE GLYCOL). Colourless syrupy liquid with sweetish taste; miscible with water. It is the main constituent of 'anti-freeze' mixtures.

HARMFUL IF TAKEN INTERNALLY

Acute Effects

Death has followed the drinking of ethanediol as a substitute for spirits (100 ml may prove fatal). Smaller quantities may result in restlessness, unsteady gait, drowsiness and coma and injury to the kidneys.

First Aid

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ETHER—see DIETHYL ETHER.

ETHYLAMINE AND SOLUTIONS. Colourless volatile liquid (b.p. 17°C) with a fishy ammoniacal odour. The solutions in water and ethanol are commonly used.

IRRITANT VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour irritates the mucous membranes and respiratory system; in high concentrations it may affect the nervous system.

The vapour and solutions irritate the eyes.

The solutions may irritate the skin.

Assumed to be irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

N-ETHYLANILINE. Colourless to brown liquid; insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

Excessive breathing of the vapour or absorption of the liquid through the skin can cause headache, drowsiness, cyanosis, mental confusion and, in severe cases, convulsions.
The liquid damages the eyes, and the above effects can be expected if it is swallowed.

Chronic Effects

Continued exposure to the vapour, or slight skin exposure to the liquid, over a period may affect the nervous system and the blood, causing fatigue, loss of appetite, headache and dizziness.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: when splashing has occurred, irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ETHYL BROMIDE—*see* BROMOETHANE.

ETHYL CHLOROACETATE. Colourless liquid with fruity odour; immiscible with water.

IRRITANT VAPOUR
INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour irritates the respiratory system.
The vapour and liquid irritate the eyes severely. Information about other effects is lacking, but it is best to assume that the liquid irritates the skin and that ingestion will lead to severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ETHYL CHLOROFORMATE (ETHYL CHLOROCARBONATE).

Colourless liquid with pungent odour; immiscible with water.

IRRITANT VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour irritates the respiratory system.
The vapour and liquid irritate the eyes severely.
The liquid irritates the skin.
Assumed to be irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ETHYLENE CHLOROHYDRIN—*see* 2-CHLOROETHANOL.

ETHYLENE DIBROMIDE (BROMIDE)—*see* 1,2-DIBROMOETHANE.

ETHYLENE DICHLORIDE (CHLORIDE)—*see* 1,2-DICHLOROETHANE.

ETHYLENEDIAMINE—*see* DIAMINOETHANE.

ETHYLENE GLYCOL—*see* 1,2-ETHANEDIOL.

ETHYLENE OXIDE. Colourless low boiling (11°C) liquid or gas with no very distinctive smell; soluble in water.

HARMFUL VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with eyes and skin.
M.A.C. 100 p.p.m.

Acute Effects

Short exposures to quite high concentrations can be tolerated, but long exposure to fairly low concentrations may cause difficulty in breathing, and vomiting.
The vapour irritates the eyes.
Excessive contact with liquid or solution can cause delayed burns and blistering.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention. Apply artificial respiration (p. 30) if breathing has stopped.
Affected eyes: irrigate with water; in severe cases or where liquid splashing has occurred, obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth with water; obtain medical attention.

ETHYL ETHER—*see* DIETHYL ETHER.

ETHYL FORMATE (FORMIC ETHER). Colourless, volatile liquid with a pleasant odour; somewhat soluble in water.

IRRITANT VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 100 p.p.m.

Acute Effects

The vapour irritates the respiratory system. Heavy concentrations affect the nervous system and can render unconscious.
The vapour and liquid irritate the eyes severely.
Assumed to be irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ETHYL SULPHATE—*see* DIETHYL SULPHATE.

FERRIC CHLORIDE ANHYDROUS. Black-brown crystals and aggregated masses; violently decomposed by water with the formation of hydrogen chloride.

CORROSIVE WHEN MOIST—CAUSES BURNS

Avoid contact with eyes and skin.

Acute Effects

Inhalation of fine crystals produces irritation or burns of the mucous membranes.
Will cause painful eye burns.
When moisture is present on skin, heat is produced on contact resulting in thermal and acid burns.
If taken by mouth the immediate local reaction would cause severe burns.

First Aid

Dust inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water and give large quantity of water to drink followed by milk of magnesia; obtain medical attention.

FLUORIDES. Colourless crystals or powders; usually soluble in water

HARMFUL DUST
HARMFUL IF TAKEN BY MOUTH

Avoid inhalation of dust. Avoid contact with eyes and skin.
M.A.C. 2·5 mg/m³.

Acute Effects

The dust irritates all parts of the respiratory tract.
The dust irritates the eyes and skin.
Nausea, vomiting, diarrhoea and abdominal pains follow ingestion.

Chronic Effects

Shortness of breath, cough, elevated temperature and cyanosis.

First Aid

Dust inhaled: remove from exposure; rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench thoroughly with water.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

FLUOROBORIC ACID AND SALTS. Fluoroboric acid is a colourless fuming liquid miscible with water. The salts are colourless, crystalline and soluble in water.

HARMFUL VAPOUR AND DUST
HARMFUL IF TAKEN INTERNALLY
CORROSIVE—CAUSES BURNS

Avoid inhaling vapour or dust. Avoid contact with eyes and skin.

Acute Effects

The vapour and dust irritate all parts of the respiratory system.
The acid and salts burn the eyes severely.
The acid burns the skin.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Vapour or dust inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench thoroughly with water; in severe cases obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

FLUOROSILICIC ACID AND SALTS. Fluorosilicic acid is a colourless fuming liquid miscible with water. The salts are colourless, crystalline and soluble in water.

HARMFUL VAPOUR AND DUST
HARMFUL IF TAKEN INTERNALLY
CORROSIVE—CAUSES BURNS

Avoid inhaling vapour or dust. Avoid contact with eyes and skin.

Acute Effects

The vapour or dust irritates all parts of the respiratory system.
The acid and salts burn the eyes severely.
The acid burns the skin.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Vapour or dust inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench thoroughly with water; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

FLUOROSULPHONIC ACID. Colourless or yellow fuming liquid; soluble in water.

IRRITANT VAPOUR
EXTREMELY CORROSIVE—CAUSES BURNS

Avoid inhaling vapour. Prevent contact with eyes and skin.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates and the liquid burns the eyes severely.
The liquid and vapour burn the skin.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench thoroughly with water; remove and wash contaminated clothing before re-use; in severe cases, obtain medical attention.
If swallowed: wash out mouth with plenty of water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

FORMALDEHYDE SOLUTION (FORMALIN). Colourless, sometimes milky solution with pungent odour.

IRRITANT VAPOUR

Avoid breathing vapour. Avoid contact with eyes and skin.
M.A.C. 5 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system.
The liquid and vapour irritate the eyes severely.
The liquid in contact with the skin has a hardening or tanning effect and causes irritation.
Severe abdominal pains with nausea and vomiting and possibly loss of consciousness follow ingestion.

Chronic Effects

High concentration of vapour inhaled for long periods can cause laryngitis, bronchitis or bronchial pneumonia.
Prolonged exposure may cause conjunctivitis.
In contact with skin for long periods will cause cracking of skin and ulceration, particularly around fingernails.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or when splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give milk freely to drink; obtain medical attention.

FORMIC ACID. Colourless liquid which fumes in the higher concentrations; miscible with water.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Avoid contact with eyes and skin.
M.A.C. 10 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates the eyes and the liquid causes painful eye burns.
The liquid burns the skin.
If taken by mouth there is severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench thoroughly with water and then bathe with 1 per cent solution of ammonia in water.
If swallowed: wash out mouth with water and give water to drink followed by milk of magnesia; obtain medical attention.

HYDRAZINE SALTS. Colourless crystals; soluble in water.

CORROSIVE—CAUSES BURNS

Avoid contact with eyes and skin.

Acute Effects

The crystals and solutions irritate or burn the eyes severely.
The crystals and solutions burn the skin.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth with plenty of water and give plenty of water to drink; obtain medical attention.

HYDRAZINE SOLUTIONS (HYDRAZINE HYDRATE). Colourless liquid; miscible with water.

CORROSIVE—CAUSES BURNS

Avoid contact with eyes and skin.

Acute Effects

The liquid burns the eyes severely.
The liquid burns the skin.
If taken by mouth there is severe internal irritation and damage.

First Aid

Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth with plenty of water and give plenty of water to drink; obtain medical attention.

HYDRIODIC ACID AND HYDROGEN IODIDE. Colourless gas dissolving in water to form a yellow or brown fuming liquid with a characteristic odour.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Avoid contact with eyes and skin.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates and the liquid burns the eyes severely.
The vapour and liquid burn the skin.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench thoroughly with water; remove and wash contaminated clothing before re-use; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

HYDROBROMIC ACID AND HYDROGEN BROMIDE. Colourless gas dissolving in water to form a colourless or yellow-brown fuming liquid.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Avoid contact with eyes and skin.
M.A.C. 5 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates and the liquid burns the eyes severely.
The vapour and liquid burn the skin.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench thoroughly with water; remove and wash contaminated clothing before re-use; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

HYDROCHLORIC ACID AND HYDROGEN CHLORIDE. Colourless gas dissolving in water to form a colourless fuming liquid.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Avoid contact with eyes and skin.
M.A.C. 5 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates the eyes and the liquid causes painful eye burns.
The liquid burns the skin.
If taken by mouth there is severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with plenty of water; give water to drink followed by milk of magnesia; obtain medical attention.

HYDROCYANIC ACID AND HYDROGEN CYANIDE (PRUSSIC ACID).

Colourless gas with a characteristic odour; soluble in water. The gas is inflammable.

POISON
EXTREMELY HARMFUL VAPOUR
EXTREMELY HARMFUL BY SKIN ABSORPTION AS SOLUTION

Avoid breathing vapour. Prevent contact with eyes and skin.
M.A.C. 10 p.p.m.

Acute Effects

The vapour is extremely poisonous; may cause headache, dizziness, a feeling of suffocation, nausea followed by unconsciousness and death.
The probability of an eye injury alone from exposure to hydrogen cyanide, and not accompanied by toxicity from inhalation or absorption, is remote.
The vapour and solution can be absorbed through the skin.
The solution is extremely poisonous if taken by mouth; respiration at first rapid but soon becomes slow and gasping, resulting in unconsciousness and death.

First Aid

Prompt treatment is of the utmost importance.
In all cases obtain medical attention.
Vapour inhaled: remove from exposure; rest, keep warm. If breathing break capsule of amyl nitrite (p. 34) and give to inhale for 15–30 seconds; repeat every 2–3 minutes. Apply artificial respiration (p. 30) if breathing has stopped.
Affected eyes: irrigate thoroughly with water.
Skin contact: drench thoroughly with water; remove and wash contaminated clothing before re-use.
If swallowed: give cyanide antidote (p. 34); if breathing break capsule of amyl nitrite and give to inhale for 15–30 seconds; repeat every 2–3 minutes. Apply artificial respiration (p. 30) if breathing has stopped.

HYDROFLUORIC ACID AND HYDROGEN FLUORIDE.

Colourless gas, dissolving in water to form a colourless fuming liquid.

EXTREMELY HARMFUL VAPOUR
EXTREMELY CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with eyes, skin and clothing.

Effects

The vapour irritates all parts of the respiratory system.
The vapour or liquid rapidly causes severe irritation of the eyes and eyelids.
Skin burns do not usually cause pain until several hours have elapsed.
If taken by mouth there is immediate and severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate immediately with cold water for at least 15 minutes; obtain medical attention.
Skin contact: irrigate immediately and continuously with cold water until medical attention is obtained. Pay particular attention to the skin under the fingernails. If medical attention is delayed apply a dilute solution of ammonia in water. Remove and wash contaminated clothing before re-use.
If swallowed: give large quantity of water to drink followed by milk of magnesia; obtain medical attention.

HYDROGEN PEROXIDE.

Colourless liquid; miscible with water.

CORROSIVE—CAUSES BURNS

Avoid contact with eyes and skin.

Acute Effects

Hydrogen peroxide, especially in higher concentrations, is irritant and caustic to the mucous membranes, eyes and skin.
If swallowed, the sudden evolution of oxygen may cause injury by acute distension of the stomach and may cause nausea, vomiting and internal bleeding.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench skin and contaminated clothing with water.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

HYDROGEN SULPHIDE (SULPHURETTED HYDROGEN). Inflammable gas, soluble in water.

EXTREMELY HARMFUL GAS
AVOID INHALING GAS

A colourless gas with an offensive odour.
M.A.C. 20 p.p.m.

Acute Effects

In high concentrations may cause immediate unconsciousness; at lower concentrations causes irritation of all parts of the respiratory system and eyes, headache, dizziness and weakness.

First Aid

Gas inhaled: remove from exposure; keep warm and rest; in severe cases, obtain medical attention. Apply artificial respiration (p. 30) if breathing has stopped.
Affected eyes: irrigate thoroughly with water.

HYDROXY-AMMONIUM SALTS (HYDROXYLAMINE SALTS). White crystals; soluble in water.

CORROSIVE—SKIN IRRITANT

Avoid contact with eyes and skin.

Acute Effects

The salts and solutions irritate and burn the eyes severely.
The salts and solutions burn the skin.
If taken by mouth there is severe internal irritation and damage.

Chronic Effects

Continued skin contact can cause dermatitis.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

IODIC ACID (IODINE PENTOXIDE). Colourless crystals or powder; soluble in water.

HARMFUL DUST
CORROSIVE—CAUSES BURNS

Avoid breathing dust. Avoid contact with eyes and skin.

Acute Effects

The dust irritates all parts of the respiratory system.
The acid and solutions burn the eyes and skin.
If taken by mouth is assumed to cause severe internal irritation and damage.

First Aid

Dust inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

IODINE. Bluish-black crystalline scales with a characteristic odour; almost insoluble in water.

HARMFUL VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Avoid contact with eyes and skin.
M.A.C. 1 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour and solid irritate the eyes.
The solid burns the skin.
If taken by mouth there is severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases obtain medical attention.
Skin contact: drench with 1 per cent solution of sodium thiosulphate in water.
If swallowed: wash out mouth thoroughly with 1 per cent solution of sodium thiosulphate in water and give some solution to drink followed by emetic; obtain medical attention.

IODINE TRICHLORIDE. Fuming, orange-red crystalline masses with pungent odour; soluble in water.

HARMFUL VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Avoid contact with eyes and skin.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour and solid irritate and burn the eyes severely.
The solid burns the skin.
Assumed to cause severe internal irritation and damage if taken by mouth.

First Aid

If inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

IODOMETHANE (METHYL IODIDE). Heavy, colourless to yellow-brown liquid with a sweetish smell; sparingly soluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Prevent contact with skin and eyes.

Acute Effects

Inhalation of vapour may cause dizziness, drowsiness, mental confusion, muscular twitching and delirium.
The vapour and liquid irritate the eyes and distort the vision.
The liquid irritates the skin and may cause blistering.
The liquid must be assumed to be irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

LEAD SALTS. White or coloured crystals or powders.

POISON

Avoid breathing dust.

Acute Effects

Dust inhaled or material swallowed may cause severe internal injury with vomiting, diarrhoea and collapse.

Chronic Effects

Loss of appetite, pallor, anaemia, constipation, colic, blue line on gums.

First Aid

If swallowed: wash out mouth thoroughly with water; give emetic, followed by solution of magnesium sulphate (Epsom salts), 30 g in 250 ml warm water; obtain medical attention.

LITHIUM HYDROXIDE. White crystals; soluble in water.

CORROSIVE—CAUSES BURNS

Avoid contact with eyes and skin.

Acute Effects

The solid and solution irritate the eyes severely and burn the skin. It is assumed that there is internal irritation and damage if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.

Skin contact: drench with water.

If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by vinegar or 1 per cent acetic acid; obtain medical attention.

MERCURY (QUICKSILVER). Heavy silvery liquid; insoluble in water

POISON
HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with eyes and skin.
M.A.C. 0·1 mg/m^3.

Acute Effects

High concentrations of vapour may cause metallic taste, nausea, abdominal pain, vomiting, diarrhoea and headache.

Chronic Effects

Continued exposure to small concentrations of vapour may result in severe nervous disturbance, including tremor of the hands, insomnia, loss of memory, irritability and depression; other possible effects are loosening of teeth and excessive salivation.

Continued skin contact with mercury may cause dermatitis and the above effects may be caused by continued absorption through the skin or following ingestion. Kidney damage may ensue.

First Aid

Vapour inhaled: remove from exposure; obtain medical attention if exposure serious.

Skin contact: if this is believed to have been prolonged, medical observation will be required.

If swallowed: obtain medical attention.

MERCURY COMPOUNDS. Mercury compounds vary widely in appearance, solubility in water and toxicity. Mercuric compounds are generally more toxic than mercurous compounds.

Some organic mercurial compounds are liquids with an extremely poisonous vapour, others are solids, the toxicity of which is not known with certainty. Thus phenyl mercuric acetate appears relatively non-toxic but the alkyl mercurials are highly poisonous. Their toxicity by skin absorption is uncertain, but some, e.g. ethyl mercury phosphate and mercury fulminate, can cause dermatitis. The effects vary greatly according to the nature of the organic mercurial. Some compounds cause kidney damage while others can cause irreversible damage to the central nervous system.

POISON
HARMFUL DUSTS
HARMFUL BY SKIN ABSORPTION

Avoid breathing dusts. Avoid contact with skin and eyes.
Avoid undue exposure.

Acute Effects

Inhalation of dust may cause nausea, abdominal pain, vomiting, diarrhoea and headache.

Skin absorption may give rise to similar effects and the eyes may be damaged by direct contact with some salts.

Abdominal pain, nausea, vomiting, diarrhoea and shock follow ingestion of the soluble mercuric salts. Kidney damage may ensue.

Chronic Effects

The intake of small amounts of mercury compounds by inhalation, skin absorption or ingestion over a long period may cause nervous disturbance, including tremor of the hands, insomnia, loss of memory, irritability and depression; other possible effects are loosening of the teeth and excessive salivation.

First Aid

Dusts inhaled: remove from exposure; obtain medical attention.

Affected eyes: irrigate thoroughly with water; obtain medical attention.

Skin contact: drench with water or, in the case of insoluble compounds, wash with soap and water; if contact has been prolonged, medical observation will be required.

If swallowed: wash out mouth thoroughly with water and give large quantity of milk to drink; obtain medical attention.

METHANOL (METHYL ALCOHOL). Colourless, volatile liquid; miscible with water.

HARMFUL VAPOUR
HARMFUL IF TAKEN INTERNALLY

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 200 p.p.m.

Acute Effects

Inhalation of high concentrations of vapour may cause dizziness, stupor, cramps and digestive disturbance. Lower concentrations may cause headache, nausea, vomiting and irritation of the mucous membranes.

The vapour and liquid are very dangerous to the eyes, the effects sometimes being delayed for many hours.

Ingestion damages the central nervous system, particularly the optic nerve (causing temporary or permanent blindness), and injures the kidneys, liver, heart and other organs; apart from the effects referred to above, unconsciousness may develop after some hours and this may be followed by death.

Chronic Effects

Continued exposure to low concentrations of vapour may cause many of the above effects.

Continued skin contact may cause dermatitis.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.

Affected eyes: irrigate thoroughly with water and obtain medical attention.

Skin contact: drench with water; remove contaminated clothing and air before re-use.

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

METHYLAMINE AND SOLUTIONS. Methylamine is a colourless gas with a fishy, ammoniacal odour; it is very soluble in water and is available commercially in aqueous and ethanolic solutions.

IRRITANT VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour irritates the respiratory system and, in high concentrations, may poison the central nervous system.

High concentrations of the vapour or solutions irritate the eyes and mucous membranes.

Assumed to be irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or if splashing has occurred, obtain medical attention.
Skin contact: drench with water, remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

N-METHYLANILINE. Colourless to brown liquid; insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

Excessive breathing of the vapour or absorption of the liquid through the skin can cause headache, drowsiness, cyanosis, mental confusion and, in severe cases, convulsions.
The liquid is dangerous to the eyes, and the above effects can also be experienced if it is swallowed.

Chronic Effects

Continued exposure to the vapour, or slight skin exposure to the liquid, over a period may affect the nervous system and the blood, causing fatigue, loss of appetite, headache and dizziness.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: when splashing has occurred, irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

METHYL BROMIDE—*see* BROMOMETHANE.

METHYL CHLOROFORMATE. Colourless liquid; immiscible with water.

IRRITANT VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour irritates the respiratory system.
The vapour irritates and the liquid burns the eyes.
The liquid can irritate and burn the skin.
Assumed to be irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in serious cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

METHYL CYANIDE (ACETONITRILE). Colourless volatile liquid smelling like acetamide; miscible with water.

POISON
EXTREMELY HARMFUL VAPOUR

Do not breathe vapour. Avoid contact with skin and eyes.
Suggested M.A.C. 20 p.p.m.

Effects

These are not recorded, but because of its chemical character, authorities assume it to be very toxic and to approximate to hydrogen cyanide in this respect.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, break capsule of amyl nitrite (p. 34) and give to inhale for 15–30 seconds, repeat every 2–3 minutes; apply artificial respiration (p. 30) if breathing has stopped; obtain medical attention.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
Skin contact: drench with water; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give cyanide antidote (p. 34); obtain medical attention.

METHYLENE CHLORIDE—*see* DICHLOROMETHANE.

METHYL IODIDE—*see* IODOMETHANE.

METHYL SULPHATE—*see* DIMETHYL SULPHATE.

NAPHTHYLAMINES AND SALTS. 1-Naphthylamine is a colourless to pink or grey solid with unpleasant smell, insoluble in water. 2-Naphthylamine is a colourless to buff solid (sometimes in flake form), insoluble in water. The hydrochlorides of both bases are soluble in water.

CARCINOGENIC
HARMFUL DUST
HARMFUL BY SKIN ABSORPTION

Do not breathe dust. Prevent contact with skin and eyes.

Acute Effects

The salts or their solutions irritate the eyes.

Chronic Effects

Prolonged exposure to the dust or prolonged absorption through the skin may cause bladder tumours. 2-Naphthylamine is especially dangerous in this respect.

Special Precautions

If appreciable amounts of the bases or salts are being handled, rubber gloves, a dust mask and goggles should be worn.

First Aid

Affected eyes: irrigate thoroughly with water; if splashing with a solution of a salt has occurred, obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

NICKEL SALTS. Green crystals or powder; mostly soluble in water.

HARMFUL DUST

Avoid breathing dust. Avoid contact with eyes and skin.

Acute Effects

The salts and their solutions will irritate the eyes.
Assumed to be poisonous if taken by mouth.

Chronic Effects

Continued skin contact can cause dermatitis.

First Aid

Inhaled dust: remove from exposure.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth with plenty of water, give an emetic (p. 29); obtain medical attention.

NITRIC ACID. Colourless or pale yellow fuming liquid; miscible with water.

IRRITANT VAPOUR
EXTREMELY CORROSIVE—CAUSES SEVERE BURNS

Avoid breathing vapour. Prevent contact with eyes and skin.
M.A.C. 10 p.p.m.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates and the liquid burns the eyes severely.
The vapour and liquid burn the skin.
If taken by mouth there is severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench thoroughly with water; remove and wash contaminated clothing before re-use; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

NITROANILINES. The nitroanilines (*o*-, *m*- and *p*-) are yellow to orange-red crystals or powders; slightly soluble in water.

HARMFUL DUSTS
HARMFUL BY SKIN ABSORPTION

Avoid breathing dusts. Avoid contact with skin and eyes.

Acute Effects

Inhalation of dusts or excessive skin absorption of the solids may result in headache, flushing of the face, difficulty in breathing, nausea and vomiting; weakness, drowsiness, irritability and cyanosis may follow.
Dermatitis may follow skin contact.
The dusts will damage the eyes and effects similar to the above may be expected if the substances are taken by mouth.

First Aid

Dust inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

NITROBENZENE (OIL OF MIRBANE). Pale yellow or yellow liquid with odour of bitter almonds; immiscible with water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 1 p.p.m.

Acute Effects

Inhalation of the vapour may cause a burning sensation in the chest, difficulty in breathing, cyanosis and, in severe cases, unconsciousness.
The liquid injures the eyes and if it is absorbed excessively through the skin may give rise to the above symptoms.
Drowsiness, vomiting, cyanosis and unconsciousness may follow ingestion.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

NITROGEN DIOXIDE (NITROUS FUMES). Nitrogen dioxide is a red-brown gas which is a common by-product of the reaction of nitric acid with metals and organic materials.

EXTREMELY HARMFUL GAS

Avoid breathing gas.
M.A.C. 25 p.p.m.

Acute Effects

Although nitrogen dioxide has some irritant effect upon the respiratory system, its danger lies in the delay before its full effects upon the lungs are shown by feelings of weakness and coldness, headache, nausea, dizziness, abdominal pain and cyanosis; in severe cases convulsions and asphyxia may follow.

First Aid

It is advisable in all cases where appreciable inhalation of nitrogen dioxide is believed to have occurred to obtain medical attention immediately, even if the person exposed is not complaining of discomfort; removal from exposure, rest and warmth are essential until under professional care.

NITROPHENOLS. *o*-Nitrophenol is more volatile than the *m*- and *p*- compounds and has a phenolic (carbolic) odour; the nitrophenols are pale yellow or yellow crystals or powders; sparingly soluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour or dust. Avoid contact with skin and eyes.

Acute Effects

Excessive intake by inhalation of the dust, absorption by the skin or ingestion may cause irritation, headache, drowsiness and cyanosis. Assumed to irritate and injure the eyes.

First Aid

Vapour or dust inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by two tablespoonfuls of magnesium sulphate (Epsom salts) in water; obtain medical attention.

***p*-NITROPHENYLHYDRAZINE.** Orange-yellow powder; sparingly soluble in water.

HARMFUL BY SKIN ABSORPTION

Avoid contact with skin and eyes.

Acute Effects

These have not been recorded but it must be assumed that intake, whether by inhalation of the dust, absorption through the skin or ingestion, will result in irritation or poisoning.
Irritation of the eyes by the dust must also be assumed.

First Aid

Dust inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

NITROSODIMETHYLANILINE—*see* *NN*-DIMETHYL-*p*-NITROSOANILINE.

1-NITROSO-2-NAPHTHOL. Yellow-brown powder; insoluble in water.

IRRITANT DUST

Avoid breathing dust. Avoid contact with skin and eyes.

Acute Effects

The dust irritates the respiratory system.
The dust irritates the eyes and skin and may cause dermatitis.
Assumed to be irritant and poisonous if taken by mouth.

First Aid

Dust inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench with water and wash with soap and water.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

NITROTOLUENES. *o*-Nitrotoluene is a yellow liquid, *m*-nitrotoluene a yellow or brown-yellow liquid or crystalline solid (m.p. 150° C) and *p*-nitrotoluene is a pale yellow or yellow crystalline solid. All are insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour or dust. Avoid contact with skin and eyes.

Acute Effects

Inhalation of vapour or dust or skin absorption may cause difficulty in breathing, cyanosis and, in severe cases, unconsciousness.
Assumed to injure the eyes and cause the above effects if taken by mouth.

First Aid

Vapour or dust inhaled: remove from exposure; rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

NITROUS FUMES—*see* NITROGEN DIOXIDE.

NORDHAUSEN ACID—*see* OLEUM.

OLEUM (FUMING SULPHURIC ACID, NORDHAUSEN ACID). Colourless to yellow viscous fuming liquid; reacts violently with water.

IRRITANT VAPOUR
EXTREMELY CORROSIVE—CAUSES SEVERE BURNS

Avoid inhaling vapour. Prevent contact with eyes and skin.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour irritates and the liquid burns the eyes severely.
The vapour and liquid burn the skin.
If swallowed there would be most severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; in severe cases obtain medical attention; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

ORTHOPHOSPHORIC ACID. Colourless viscous liquid; miscible with water.

CORROSIVE—CAUSES BURNS

Avoid contact with eyes and skin.

Acute Effects

The liquid burns the eyes severely.
The liquid burns the skin.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench thoroughly with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

OSMIC ACID (OSMIUM TETROXIDE). Colourless or pale yellow crystals with pungent odour; soluble in water.

HARMFUL VAPOUR
CORROSIVE—CAUSES BURNS

Avoid inhaling vapour. Prevent contact with eyes and skin.

Acute Effects

The vapour irritates all parts of the respiratory system.
The vapour, solid and solution irritate and burn the eyes severely.
The acid and its solution burn the skin.
If taken by mouth there would be severe internal irritation and damage.

Chronic Effects

Continued exposure to vapour causes disturbances of the vision.
Continued skin contact results in dermatitis and ulceration.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where contact has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

OXALATES. Most oxalates are colourless; ammonium, sodium and potassium oxalates are soluble in water.

HARMFUL IF TAKEN INTERNALLY

Avoid contact with eyes and skin.

Acute Effects

If swallowed there would be severe internal pain followed by collapse.

First Aid

Affected eyes: irrigate thoroughly with water.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

OXALIC ACID. Colourless crystals; soluble in water.

HARMFUL DUST
HARMFUL IF TAKEN INTERNALLY

Avoid contact with eyes and skin.

Acute Effects

The dust irritates the respiratory system.
The dust and solutions irritate the eyes.
If swallowed there would be severe internal pain followed by collapse.

First Aid

Dust inhaled: remove from exposure; rest and keep warm; obtain medical attention.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

OXALYL CHLORIDE. Colourless fuming liquid with acrid odour; reacts vigorously with water forming hydrochloric and oxalic acids.

EXTREMELY IRRITANT VAPOUR

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour irritates the respiratory system severely.
The vapour and liquid irritate the eyes.
The liquid irritates the skin and must be assumed to be very irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

PENTACHLOROETHANE. Colourless, heavy liquid of relatively low volatility with chloroform-like odour; immiscible with water.

EXTREMELY HARMFUL VAPOUR

Avoid breathing vapour. Avoid contact with eyes.

Acute Effects

The vapour irritates the eyes, nose and lungs and may cause drowsiness, giddiness, headache, and in high concentrations, unconsciousness.
Assumed to be poisonous if taken by mouth.

Chronic Effects

Continuous breathing of low concentrations of vapour over a long period may cause jaundice by action on the liver. It may also affect the nervous system and the blood.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; where splashing has occurred, obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

PENTACHLOROPHENOL AND SODIUM PENTACHLOROPHENATE. Pentachlorophenol is a colourless to yellow crystalline solid with a phenolic (carbolic) odour, insoluble in water. The sodium salt is a buff powder or flaked solid, soluble in water.

HARMFUL DUST
HARMFUL BY SKIN ABSORPTION

Avoid breathing dust. Avoid contact with skin and eyes.

Acute Effects

The dusts irritate the nose and eyes.
Absorption through the skin or ingestion may cause accelerated breathing, feverishness and muscular weakness; in severe cases, convulsions and unconsciousness may follow. Skin contact may cause dermatitis.

First Aid

Dust inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give water to drink followed by two tablespoonfuls of magnesium sulphate (Epsom salts) in water; obtain medical attention.

PERCHLORIC ACID. Colourless liquid; miscible with water.

CORROSIVE—CAUSES BURNS

Prevent contact with eyes and skin.

Acute Effects

Burns the eyes and skin severely.
Assumed to cause severe internal irritation and damage if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give water to drink followed by milk of magnesia; obtain medical attention.

PERCHLOROETHYLENE—*see* TETRACHLOROETHYLENE.

PHENACYL BROMIDE—AS PHENACYL CHLORIDE (*see below*).

PHENACYL CHLORIDE. Colourless to yellow crystals or powder; insoluble in water.

IRRITANT VAPOUR AND DUST

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour and dust irritate the respiratory system and skin; they irritate the eyes severely.
Assumed to be very irritant if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

PHENETIDINES. *o*-, *m*- and *p*-Phenetidines are red to brown liquids; immiscible with water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Effects

These are not recorded, but are assumed to be similar to those of aniline poisoning, *i.e.* headache, drowsiness and cyanosis.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in the case of splashing, obtain medical attention.

Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

PHENOL (CARBOLIC ACID). Colourless to pink crystalline substance with distinctive odour; somewhat soluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 5 p.p.m.

Acute Effects

The vapour irritates the respiratory system and eyes. Skin contact causes softening and whitening followed by the development of painful burns; its rapid absorption through the skin may cause headache, dizziness, rapid and difficult breathing, weakness and collapse.
If taken by mouth it causes severe burns, abdominal pain, nausea, vomiting and internal damage.

Chronic Effects

The inhalation of vapour over a long period may cause digestive disturbance, nervous disorders, skin eruptions and damage to the liver and kidneys.
Dermatitis may result from prolonged contact with weak solutions.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: wash very thoroughly with soap and water; remove and wash contaminated clothing before re-use; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water, give plenty of water to drink followed by two tablespoonfuls of magnesium sulphate (Epsom salts) in water; obtain medical attention.

PHENOL-DISULPHONIC AND -SULPHONIC ACIDS—*see* SULPHONIC ACIDS.

PHENYLACETONITRILE—*see* BENZYL CYANIDE.

PHENYLENEDIAMINES. *p*-Phenylenediamine—pale mauve to mauve crystals or powder. *m*-Phenylenediamine—colourless to brown or black crystals or lumps. Both substances are soluble in water.

HARMFUL BY SKIN ABSORPTION

Avoid contact with skin and eyes.

Acute Effects

Eye irritation and injury follow contact.
May irritate the skin causing dermatitis; the skin becomes blackened.
Assumed to be poisonous if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

PHENYLHYDRAZINE AND HYDROCHLORIDE. Phenylhydrazine is a yellow to red-brown liquid or solid (m.p. 19° C), insoluble in water. The hydrochloride consists of colourless to brown crystals or powder, soluble in water.

HARMFUL VAPOUR OR DUST
HARMFUL BY SKIN ABSORPTION

Avoid inhalation of vapour or dust. Avoid contact with skin and eyes.

Acute Effects

Absorption resulting from inhalation, skin contact or ingestion may result in blood and liver damage, giving rise to nausea, vomiting and jaundice.
Dermatitis may follow skin contact.
Must be considered injurious to the eyes.

First Aid

Vapour or dust inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

PHENYL MERCURY SALTS—*see* MERCURY COMPOUNDS.

PHOSGENE (CARBONYL CHLORIDE) **AND SOLUTIONS.** The gas is colourless and has a musty smell. Solutions of the gas in benzene and toluene (HIGHLY INFLAMMABLE) are available commercially.

EXTREMELY HARMFUL GAS

Do not breath gas. Avoid contact of solutions with skin and eyes.
M.A.C. 1 p.p.m.

Acute Effects

The gas produces delayed secretion of fluid into the lung (pulmonary oedema) when inhaled and there may be delay of several hours before effects develop. These include breathlessness, cyanosis and the coughing up of frothy fluid.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; if inhalation has been considerable medical observation is essential.
Affected eyes: irrigate thoroughly with water when splashing by a solution has occurred; obtain medical attention.
Skin contact with solution: wash thoroughly with soap and water; remove and air contaminated clothing before re-use.
If solution swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

PHOSPHORIC ACID—*see* ORTHOPHOSPHORIC ACID.

PHOSPHORIC OXIDE (PHOSPHORUS PENTOXIDE). White crystalline deliquescent powder; reacts violently with water.

HARMFUL DUST
CORROSIVE—CAUSES BURNS

DO NOT PUT WATER INTO CONTAINERS

Avoid contact with eyes and skin.

Acute Effects

The dust irritates all parts of the respiratory system, burns the eyes severely and burns the skin.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Dust inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

PHOSPHORUS (YELLOW). Pale yellow, waxy, translucent solid; usually stored under water. If exposed to the air it is rapidly oxidized and ignites spontaneously, giving off oxide fumes.

CAUSES SEVERE, VERY PAINFUL BURNS

Prevent contact with eyes and skin.

Acute Effects

The vapour from ignited phosphorus irritates the nose, throat, lungs, mucous membranes and eyes.
The solid burns the eyes and skin.
Assumed to cause severe internal damage if taken by mouth.

Chronic Effects

Continued absorption of small amounts of phosphorus can cause anaemia, intestinal weakness, pallor, and bone and liver damage.

First Aid

Vapour of burning phosphorus inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench with plenty of water and then swab for 15 minutes with a 3 per cent solution of copper sulphate in water (this will convert the phosphorus to a black copper salt which can be readily seen and removed); obtain medical attention.
If swallowed: wash out mouth thoroughly with water; give emetic (p. 29); obtain medical attention.

PHOSPHORUS OXYCHLORIDE—*see* PHOSPHORYL CHLORIDE.

PHOSPHORUS PENTACHLORIDE. White to pale yellow, fuming, crystalline masses with pungent, unpleasant odour. Violently decomposed by water with formation of hydrochloric acid and phosphoric acid.

IRRITANT VAPOUR AND DUST
CORROSIVE—CAUSES BURNS

Avoid breathing vapour and dust. Prevent contact with eyes and skin.
M.A.C. 1 mg/m^3.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

Vapour and dust severely irritate the mucous membranes and all parts of the respiratory system.
The vapour severely irritates and the solid burns the eyes.
The vapour and solid burn the skin.
If taken by mouth there would be severe internal irritation and damage.

Chronic Effects

Continued exposure to low concentrations of vapour may cause damage to lungs.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

PHOSPHORUS PENTASULPHIDE AND PHOSPHORUS TRISULPHIDE. Yellow crystalline powders with a peculiar odour; react with water, forming phosphorus acids and hydrogen sulphide.

IRRITANT DUST
CORROSIVE—CAUSES BURNS

Avoid breathing dust. Avoid contact with eyes and skin.
M.A.C. 1 mg/m³.

Acute Effects

The dust irritates the mucous membranes and all parts of the respiratory system, irritates the eyes and burns the skin.
Assumed to cause severe internal irritation and damage if taken by mouth.

First Aid

Dust inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with and give water to drink followed by milk of magnesia; obtain medical attention.

HOSPHORUS PENTOXIDE—*see* PHOSPHORIC OXIDE.

HOSPHORUS TRIBROMIDE. Colourless fuming liquid; reacts violently with water, giving hydrobromic acid and phosphorous acid.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with eyes and skin.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

Vapour severely irritates the mucous membranes and all parts of the respiratory system.
The vapour irritates and the liquid burns the eyes.
The vapour and liquid burn the skin.
Assumed to cause severe internal irritation and damage if taken by mouth.

Chronic Effects

Continued exposure to low concentrations of vapour may cause damage to lungs.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

PHOSPHORUS TRICHLORIDE. Colourless fuming liquid; violently decomposed by water forming hydrochloric acid and phosphorous acid.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with eyes and skin.
M.A.C. 1 p.p.m.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

Vapour severely irritates the mucous membranes and all parts of the respiratory system.
The vapour and liquid burn the eyes and skin.
Assumed to cause severe internal irritation and damage if taken by mouth.

Chronic Effects

Continued exposure to low concentrations of vapour may cause lung damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occured, obtain medical attention.

Skin contact: drench with water; remove and wash contaminated clothing before re-use; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

PHOSPHORUS TRISULPHIDE—*see* PHOSPHORUS PENTASULPHIDE.

PHOSPHORYL CHLORIDE (PHOSPHORUS OXYCHLORIDE). Colourless fuming liquid; violently decomposed by water, giving hydrochloric acid and phosphoric acid.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Avoid contact with eyes and skin.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

The vapour severely irritates the mucous membranes and all parts of the respiratory system.
The vapour severely irritates the eyes and skin.
The liquid burns the eyes and skin.
Assumed to cause severe internal irritation and damage if taken by mouth.

Chronic Effects

Continued exposure to low concentrations of vapour may cause damage to lungs.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give water to drink followed by milk of magnesia; obtain medical attention.

PICRIC ACID. Picric acid (yellow crystals) should be kept moist with not less than half its own weight of water. It is commonly used in alcoholic solutions in the laboratory.

HARMFUL IF TAKEN EXTERNALLY
EXPLOSIVE WHEN DRY

Avoid contact with skin and eyes.

Acute Effects

Skin contact may result in dermatitis.
Poisonous if taken by mouth.

Chronic Effects

Absorption through the skin or inhalation of dust over a long period may result in skin eruptions, headache, nausea, vomiting or diarrhoea; the skin may become yellow.

First Aid

Affected eyes: irrigate thoroughly with water.
Skin contact: wash thoroughly with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of milk to drink; obtain medical attention.

POTASSIUM (METAL). Soft silvery white masses normally coated with a grey oxide or hydroxide skin; reacts violently with water with the formation of potassium hydroxide and hydrogen gas, which will ignite.

CORROSIVE—CAUSES BURNS
INFLAMMABLE ON CONTACT WITH WATER

Avoid contact with skin and eyes.
DO NOT PUT WATER IN CONTAINER

Acute Effects

The metal in contact with moisture on the skin can cause thermal and caustic burns. In the same way the potassium hydroxide resulting from the reaction of the metal with water can cause burning of the skin and eyes.

First Aid

Affected eyes: irrigate very thoroughly with water and obtain medical attention.
Skin contact: drench with water after removing adhering metal; except where contact has been slight, obtain medical attention.
Mouth contact: wash out mouth thoroughly with water; obtain medical attention.

POTASSIUM ANTIMONATE—*see* ANTIMONY COMPOUNDS.

POTASSIUM ARSENATE AND ARSENITE—*see* ARSENIC COMPOUNDS.

POTASSIUM BICHROMATE—*see* CHROMATES AND DICHROMATES.

POTASSIUM BISULPHATE—*see* POTASSIUM HYDROGEN SULPHATE.

POTASSIUM CHROMATE—*see* CHROMATES AND DICHROMATES.

POTASSIUM CYANIDE—*see* CYANIDES.

POTASSIUM DICHROMATE—*see* CHROMATES AND DICHROMATES.

POTASSIUM FLUORIDE—*see* FLUORIDES.

POTASSIUM HYDROGEN FLUORIDES—*see* FLUORIDES.

POTASSIUM HYDROGEN SULPHATE (POTASSIUM BISULPHATE). Colourless crystals or fused masses soluble in water.

CORROSIVE—CAUSES BURNS

Avoid contact with skin and eyes.

Acute Effects

The solid and its solutions severely irritate and burn the eyes and skin.
If taken by mouth there is severe internal irritation and damage.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

POTASSIUM HYDROXIDE (CAUSTIC POTASH). Colourless sticks flakes, powder or pellets soluble in water.

CORROSIVE—CAUSES BURNS

Prevent contact with eyes and skin.

Acute Effects

The solid and its solutions severely irritate and burn the eyes and skin.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Affected eyes: irrigate very thoroughly with water; obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by vinegar or 1 per cent acetic acid; obtain medical attention.

POTASSIUM SELENATE AND SELENITE—*see* SELENIUM COMPOUNDS.

POTASSIUM TELLURITE—*see* TELLURIUM COMPOUNDS.

PROPYLAMINES. The primary propylamines (*n*- and *iso*-) are colourless, volatile liquids with an ammoniacal odour; miscible with water.

HARMFUL VAPOUR
MAY CAUSE BURNS
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 5 p.p.m.

Acute Effects

The vapour irritates the respiratory system.
The vapour and liquid irritate and may burn the eyes.
The liquid may cause skin burns.
Assumed to be very irritant and poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

PRUSSIC ACID—*see* HYDROCYANIC ACID.

PYRIDINE. Colourless liquid with a sharp penetrating odour; miscible with water.

HARMFUL VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 10 p.p.m.

Acute Effects

The vapour irritates the respiratory system and may cause headache, nausea, giddiness and vomiting.
The vapour and liquid irritate the eyes and may cause conjunctivitis.
The liquid may irritate the skin causing dermatitis.
Affects the central nervous sytem if taken by mouth and large doses act as a heart poison.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

PYROCATECHOL—*see* CATECHOL.

QUINONE—*see* *p*-BENZOQUINONE.

RESORCINOL. Colourless to pink crystals; soluble in water.

HARMFUL BY SKIN ABSORPTION

Avoid contact with skin and eyes.

Acute Effects

Absorption by the skin may result in itching and dermatitis; in severe cases, restlessness, cyanosis and convulsions may follow.
The solid irritates the eyes.
It may cause dizziness, drowsiness and tremors if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water, give plenty of water to drink followed by two tablespoonfuls of magnesium sulphate (Epsom salts) in water; obtain medical attention.

SELENIUM AND COMPOUNDS. Steel grey or purplish powder, pellets, sticks or plates, insoluble in water. Selenium dioxide, selenous acid and the alkali-metal selenites and selenates are colourless powders or crystals, soluble in water; selenium chloride (reddish yellow), selenyl chloride (colourless or yellow) and selenic acid

(colourless) are liquids, whereas selenium tetrachloride is a cream-coloured crystalline solid. Highly poisonous hydrogen selenide (offensive smell) is generated when an acid solution of a selenium compound is reduced by metals such as tin and zinc. Selenic aid reacts vigorously with water.

HARMFUL DUST
HARMFUL IF TAKEN INTERNALLY

Avoid breathing dust. Avoid contact with skin and eyes.
M.A.C. (selenium) 0·1 mg/m³.

Acute Effects

Hydrogen selenide irritates the nose and eyes and causes inflammation of the lungs and disturbance of the digestive and nervous systems; it imparts a garlic-like odour to the breath.
The chloride and solutions of the acids and salts may burn the skin —severe pain may be experienced under the finger-nails by skin absorption at the finger-tips.
Selenium dioxide dust is particularly penetrating and irritates the respiratory system, eyes and skin.
Assumed to be irritant and poisonous if taken by mouth.

Chronic Effects

Inhalation of selenium dust over a prolonged period may cause fatigue, loss of appetite, digestive disturbance and bronchitis.
Dermatitis may result from prolonged exposure of skin to small amounts of selenium and its compounds.

First Aid

Dust or vapour inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

SILICON TETRACHLORIDE (SILICON CHLORIDE). Colourless fuming liquid; reacts violently with water, forming hydrochloric acid and silica.

HARMFUL VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with eyes and skin.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

The vapour severely irritates all parts of the respiratory system.
The vapour severely irritates the eyes and the liquid burns the eyes and skin.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by milk of magnesia; obtain medical attention.

SILVER NITRATE (LUNAR CAUSTIC). White crystals; soluble in water.

CORROSIVE—CAUSES BURNS

Avoid contact with eyes and skin.

Acute Effects

The solid and its solutions severely irritate the eyes and can cause skin burns.
If taken by mouth silver nitrate can cause internal damage due to absorption in the blood followed by deposition of silver in various tissues of the body.

First Aid

Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water.
If swallowed: wash out mouth thoroughly with water and give emetic (salt and water, p. 29); obtain medical attention.

SODA ASBESTOS. Grey or brown granules; largely soluble in water.

HARMFUL DUST
CORROSIVE—CAUSES BURNS

Avoid breathing dust. Prevent contact with eyes and skin.

Acute Effects

The dust severely irritates the nose and mouth.
The solid and dust burn the eyes and skin.
If swallowed there would be severe internal irritation and damage.

First Aid

Dust inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by vinegar or 1 per cent acetic acid; obtain medical attention.

SODAMIDE (SODIUM AMIDE). Colourless or greyish white lumps or powder smelling of ammonia. Reacts violently with water with the formation of sodium hydroxide and ammonia.

HARMFUL DUST

CORROSIVE—CAUSES BURNS

Avoid breathing dust. Prevent contact with eyes and skin.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

The dust severely irritates the mouth and nose.
The solid and dust severely irritate or burn the eyes.
The solid in contact with moisture on the skin can cause thermal and caustic burns.
If taken by mouth there would be severe internal irritation and damage.

First Aid

Dust inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water; give plenty of water to drink followed by vinegar or 1 per cent acetic acid; obtain medical attention.

SODIUM METAL AND SODIUM AMALGAM. Sodium—soft, silvery white sticks, pellets, wire or granules, normally coated with a grey oxide or hydroxide skin; reacts vigorously with water with formation of sodium hydroxide and hydrogen gas which may ignite. Sodium amalgam—silvery or grey spongy masses; reacts with water forming sodium hydroxide and hydrogen gas.

CORROSIVE—CAUSES BURNS

INFLAMMABLE ON CONTACT WITH WATER

Prevent contact with skin and eyes.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

The metal or amalgam in contact with moisture on the skin can cause thermal and caustic burns. In the same way the sodium hydroxide resulting from the reaction of the metal with water can cause burning of the skin and eyes.

First Aid

Affected eyes: irrigate very thoroughly with water and obtain medical atttention.
Skin contact: drench with water after removing adhering metal; except where contact has been slight, obtain medical attention.
Mouth contact: wash out mouth thoroughly with water; obtain medical attention.

SODIUM ARSENATE AND ARSENITE—*see* ARSENIC AND COMPOUNDS.

SODIUM AZIDE. Colourless crystalline powder; soluble in water.

HARMFUL BY SKIN ABSORPTION
EXPLOSIVE WHEN HEATED OR SHOCKED

Prevent contact with skin and eyes.

Acute Effects

The dust and solution irritate the eyes.
The solid and solution irritate the skin and can cause blistering.
Assumed to be very irritant and poisonous if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

SODIUM CHROMATE—*see* CHROMATES AND DICHROMATES.

SODIUM BISULPHATE—*see* SODIUM HYDROGEN SULPHATE.

SODIUM CYANIDE—*see* CYANIDES.

SODIUM DICHROMATE—*see* CHROMATES AND DICHROMATES.

SODIUM ETHOXIDE (SODIUM ETHYLATE) **AND SODIUM METHOXIDE** (SODIUM METHYLATE). Although these compounds are sometimes used industrially as solids, they are more frequently prepared in the laboratory by reacting sodium metal with ethanol and methanol. The hazards of these solutions are dealt with here.

CORROSIVE—CAUSE BURNS
HIGHLY INFLAMMABLE

Avoid contact with skin and eyes.

Acute Effects

The solutions are extremely irritant to the eyes, causing burns.
The solutions irritate the skin and may produce burns.
They will cause severe internal irritation and damage if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench thoroughly with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by vinegar or 1 per cent acetic acid; obtain medical attention.

SODIUM FLUORIDE—*see* FLUORIDES.

SODIUM FLUOROBORATE—*see* FLUOROBORIC ACID AND SALTS.

SODIUM FLUOROSILICATE—*see* FLUOROSILICIC ACID AND SALTS.

SODIUM HYDROGEN DIFLUORIDE—*see* FLUORIDES.

SODIUM HYDROGEN SULPHATE (SODIUM BISULPHATE). Colourless crystals or fused masses, soluble in water.

CORROSIVE—CAUSES BURNS

Avoid contact with skin and eyes.

Acute Effects

The solid and its solutions cause severe burns of the eyes skin.
Causes severe internal irritation and damage if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and given plenty of water to drink followed by milk of magnesia; obtain medical attention.

SODIUM HYDROXIDE (CAUSTIC SODA). Colourless sticks, flakes, powder or pellets; soluble in water.

CORROSIVE—CAUSES BURNS

Prevent contact with eyes and skin.

Acute Effects

The solid and its solutions cause severe burns of the eyes and skin. If taken by mouth, there would be severe internal irritation and damage.

First Aid

Affected eyes: irrigate very thoroughly with water; obtain medical attention.

Skin contact: drench with water; remove and wash contaminated clothing before re-use.

If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by vinegar or 1 per cent acetic acid; obtain medical attention.

SODIUM HYPOCHLORITE SOLUTION. Colourless solution smelling of chlorine.

CORROSIVE—CAUSES BURNS

Avoid contact with the skin and eyes.

Acute Effects

Extremely irritating to the eyes and gives rise to burns.
Bleaches and may burn the skin.
Will cause internal irritation and damage if ingested.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.

Skin contact: drench with water; remove and wash contaminated clothing before re-use.

If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

SODIUM METHOXIDE (SODIUM METHYLATE)—*see* SODIUM ETHOXIDE.

SODIUM OXALATE—*see* OXALIC ACID AND OXALATES.

SODIUM PEROXIDE. Pale yellow powder; reacts violently with water forming sodium hydroxide and oxygen.

HARMFUL DUST
CORROSIVE—CAUSES BURNS

Do not breathe dust. Prevent contact with skin and eyes.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

The dust irritates the respiratory system and eyes.
Because of the vigour of its reaction with water it may cause thermal and caustic burns on moist skin.
Would cause severe internal irritation and damage if taken by mouth.

First Aid

Dust inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water and obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by vinegar or 1 per cent acetic acid; obtain medical attention.

SODIUM PYROSULPHATE. Colourless powder or fused masses; soluble in water.

CORROSIVE—CAUSES BURNS

Avoid contact with skin and eyes.

Acute Effects

The solid and its solutions severely burn the eyes and skin.
Causes severe internal irritation and damage if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water; obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

SODIUM SELENATE AND SELENITES—see SELENIUM AND COMPOUNDS.

SODIUM SULPHIDE. The hydrated salt consists of colourless crystalline masses; the fused salt forms brownish lumps or powder; soluble in water. With acids, poisonous hydrogen sulphide gas is evolved.

CORROSIVE—CAUSES BURNS

Avoid contact with skin and eyes.

Acute Effects

The solid or solution cause severe burns of the eyes.
The solid or solution may irritate and burn the skin.
Irritant and poisonous if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

SODIUM VANADATE—*see* VANADIUM COMPOUNDS.

STANNIC CHLORIDE ANHYDROUS. Colourless fuming liquid; reacts with water forming hydrochloric acid.

IRRITANT VAPOUR

Avoid contact with skin and eyes.

Acute Effects

The vapour irritates the respiratory system.
The vapour irritates the eyes.
The liquid irritates the eyes and skin and may cause burns.
Will result in internal irritation and damage if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

SULPHONIC ACIDS. The simpler sulphonic acids, such as benzenesulphonic, benzenedisulphonic, phenolsulphonic, phenoldisulphonic, and cresolsulphonic acids are generally supplied as solutions in water or sulphuric acid. *p*-Toluenesulphonic acid is a colourless, hydroscopic solid.

CORROSIVE—CAUSE BURNS

Avoid contact with skin and eyes.

Acute Effects

The solutions irritate the skin and eyes and may cause burns.
Will cause internal irritation and damage if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

SULPHUR CHLORIDE. Yellow-brown, fuming liquid with a suffocating odour; decomposed by water with formation of hydrochloric acid, sulphur dioxide and sulphur.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with skin and eyes.
M.A.C. 1 p.p.m.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

The vapour irritates the respiratory system.
The vapour and liquid irritate the eyes and skin severely and the liquid may cause burns.
Its ingestion would result in severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use; burns require medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

SULPHUR DICHLORIDE. Red-brown, fuming liquid; decomposed by water with the liberation of sulphur dioxide and hydrogen chloride.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with skin and eyes.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

The vapour irritates the respiratory system.
The vapour and liquid irritate the eyes severely and the liquid may cause burns.
The liquid irritates the skin and may cause burns; its ingestion would result in severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use; burns require medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

SULPHUR DIOXIDE. Colourless gas with a distinctive odour; supplied in liquefied form in syphons or cylinders; somewhat soluble in water.

IRRITANT GAS
AVOID INHALATION OF GAS

M.A.C. 10 p.p.m.

Acute Effects

The vapour irritates the respiratory system and may cause bronchitis and asphyxia.
High concentrations of vapour irritate the eyes and may cause conjunctivitis.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.

SULPHURETTED HYDROGEN—*see* HYDROGEN SULPHIDE.

SULPHURIC ACID (VITRIOL). Concentrated sulphuric acid is a colourless, viscous liquid reacting vigorously with water.

CORROSIVE—CAUSES BURNS

Prevent contact with skin and eyes.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

The concentrated acid burns the eyes and skin severely.
The dilute acid irritates the eyes and may cause burns; it will irritate the skin and may give rise to dermatitis.
The concentrated acid, if taken by mouth, will cause severe internal irritation and damage.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use; burns require medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

SULPHURYL CHLORIDE. Colourless or yellow, fuming liquid with a pungent odour; decomposed by water with formation of hydrochloric and sulphuric acids.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with skin and eyes.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

The vapour irritates the respiratory system.
The vapour and liquid irritate the eyes and the liquid will cause burns.
The liquid irritates the skin and causes burns; its ingestion would result in severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use; burns require medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

TELLURIUM AND COMPOUNDS. Metallic ingots breaking with a white lustrous fracture, or a greyish-black powder. Telluric acid and the alkali-metal tellurites and tellurates are colourless powders or crystals, soluble in water; tellurium oxide (TeO_2) is also colourless, but is insoluble in water. Tellurium tetrachloride is a cream-coloured solid. Poisonous hydrogen telluride (offensive smell) is generated when an acid solution of a tellurium compound is reduced by metals such as tin and zinc.

HARMFUL DUST
HARMFUL IF TAKEN INTERNALLY

Avoid breathing dust. Avoid contact with skin and eyes.
M.A.C. (tellurium) 0·1 mg/m^3.

Acute Effects

Inhalation of dust or tellurium fume gives rise to a dry mouth, metallic taste, drowsiness, loss of appetite, excessive salivation, nausea, vomiting and a foul garlic-like odour of the breath.

Skin absorption and ingestion also result in foul breath and it can be assumed that effects similar to those of inhalation will be experienced. Ingestion of soluble tellurium salts may, in addition, lead to cyanosis and unconsciousness.

Chronic Effects

These are similar to the above, but arise from prolonged absorption of very small amounts of tellurium compounds.

First Aid

Inhalation of dust or fume: remove from exposure, rest and keep warm.

Affected eyes: irrigate thoroughly with water and obtain medical attention.

Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.

If swallowed: wash out throughly with water and give emetic (p. 29); obtain medical attention.

TETRABROMOETHANE (ACETYLENE TETRABROMIDE). Very heavy yellowish liquid with chloroform-like odour; immiscible with water.

HARMFUL VAPOUR

Avoid breathing vapour. Avoid contact with eyes.

Acute Effects

Records of these have not been traced though it is suggested that it has narcotic properties and may cause damage to the liver. It is probably similar in action to tetrachloroethane though not so toxic.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.

Affected eyes: irrigate thoroughly with water; where splashing has occurred, obtain medical attention.

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

TETRACHLOROETHANE. Colourless, heavy liquid with chloroform-like odour; immiscible with water.

EXTREMELY HARMFUL VAPOUR

Avoid breathing vapour. Avoid contact with eyes.
M.A.C. 5 p.p.m.

Acute Effects

The vapour irritates the eyes, nose and lung and may cause drowsiness, giddiness and headache and, in high concentrations, unconsciousness.
Assumed to be poisonous if taken by mouth.

Chronic Effects

Continuous breathing of low concentrations of vapour over a period may cause jaundice by action on the liver; it may also affect the nervous system and blood.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases obtain medical attention.
Affected eyes: irrigate thoroughly with water; where splashing has occurred, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

TETRACHLOROETHYLENE (PERCHLOROETHYLENE). Colourless liquid with faint etheral odour; immiscible with water.

HARMFUL VAPOUR

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 200 p.p.m.

Acute Effects

The inhalation of vapour may cause dizziness, nausea and vomiting —in high concentrations, stupor.
The liquid irritates the eyes and has a degreasing action on the skin.
Assumed to cause symptoms similar to those of inhalation if taken by mouth.

First Aid

Vapour inhaled: remove from exposure; rest and keep warm.
Affected eyes: irrigate thoroughly with water; where splashing has occurred, obtain medical attention.
Skin contact: wash thoroughly with soap and water.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

THALLIUM AND SALTS. Thallium—soft, silvery sticks often stored under water. The carbonate, nitrate and sulphate are colourless, crystalline solids, soluble in water; the oxide is black and insoluble in water.

POISON
HARMFUL DUST

Avoid breathing dust. Avoid contact with skin and eyes.
M.A.C. (soluble compounds) 0·1 mg/m^3.

Acute Effects

The dust irritates the nose and eyes and may cause nausea and abdominal pain by absorption.

The metal on contact with the moist skin produces a white film of the hydroxide.

Skin absorption of the soluble salts and ingestion may cause nausea, vomiting, abdominal pains, weakness of the legs and mental confusion.

Chronic Effects

Exposure over a long period to small amounts of the dust or solutions may result in loss of appetite, falling out of hair, pain or weakness of limbs, insomnia and mental disturbance.

First Aid

Dust inhaled: remove from exposure and wash out nose and mouth with water; rest and keep warm.

Affected eyes: irrigate thoroughly with water.

Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.

If swallowed: wash out mouth thoroughly with water and, if vomiting has not occurred, give emetic (salt and water, p. 29); obtain medical attention.

THIOGLYCOLLIC ACID. Colourless liquid with unpleasant smell; miscible with water. It is readily decomposed with liberation of poisonous hydrogen sulphide.

CORROSIVE—CAUSES BURNS

Avoid contact with skin and eyes.

Acute Effects

The liquid irritates the eyes and skin and may cause burns. It must be assumed to be irritant and poisonous if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.

Skin contact: drench with water and wash with soap and water.

If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

THIONYL CHLORIDE. Pale yellow or yellow fuming liquid with an odour like sulphur dioxide; it reacts with water to form hydrochloric acid and sulphur dioxide.

IRRITANT VAPOUR
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Prevent contact with skin and eyes.

DO NOT PUT WATER INTO CONTAINERS

Acute Effects

The vapour irritates the respiratory system.
The vapour irritates the eyes and skin and the liquid causes burns. Its ingestion would result in severe internal irritation and damage.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use; burns require medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

TITANIC CHLORIDE (TITANIUM TETRACHLORIDE). Colourless, fuming liquid with a pungent odour; reacts with water with liberation of hydrogen chloride.

IRRITANT VAPOUR

Avoid breathing vapour. Prevent contact with skin and eyes.

Acute Effects

The vapour irritates the respiratory system.
The vapour and liquid irritate the eyes and may cause burns.
The liquid irritates the skin.
Assumed to cause severe internal irritation and damage if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

TOLUENE (TOLUOL). Colourless liquid with characteristic odour; immiscible with water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 200 p.p.m.

Acute Effects

Inhalation of the vapour may cause dizziness, headache, nausea and mental confusion.
The vapour and liquid irritate the eyes and mucous membranes.
Absorption through the skin and ingestion would cause poisoning.

Chronic Effects

If the toluene contains benzene as an impurity, breathing of vapour over long periods may cause blood disease.
Prolonged skin contact may cause dermatitis.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and air contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

TOLUIDINES. *o*-Toluidine and *m*-toluidine are red to dark-brown liquids; *p*-toluidine consists of pale brown crystals. Insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

Excessive breathing of the vapour or absorption through the skin may cause headache, drowsiness, cyanosis, mental confusion and, in severe cases, convulsions.
They are dangerous to the eyes and the above effects may also be experienced if they are taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: when splashing has occurred irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

TRICHLOROACETIC ACID. Colourless, hygroscopic crystals; soluble in water.

CORROSIVE—CAUSES BURNS

Prevent contact with skin and eyes.

Acute Effects

Severely irritates the eyes and skin, producing blisters after a latent period.
Assumed to cause severe irritation and damage if taken by mouth.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use; blisters must receive medical attention.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by milk of magnesia; obtain medical attention.

TRICHLOROETHYLENE. Colourless liquid with sweetish chloroform-like odour; immiscible with water.

HARMFUL VAPOUR

Avoid breathing vapour. Avoid contact with skin and eyes.
M.A.C. 200 p.p.m.

Acute Effects

Inhalation of the vapour may cause headache, dizziness and nausea—with high concentrations, unconsciousness.
The vapour and liquid irritate the eyes.
Ingestion produces similar effects to inhalation of the vapour.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

ααα-TRICHLOROTOLUENE—*see* BENZOTRICHLORIDE.

TRICRESYL PHOSPHATE—*see* TRITOLYL PHOSPHATE.

TRIMETHYLAMINE AND SOLUTIONS. Colourless gas with fishy odour that clings to clothes; available in liquefied form in cylinders and also in aqueous and ethanolic solutions.

IRRITANT VAPOUR
HIGHLY INFLAMMABLE

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour irritates the mucous membranes and respiratory system; in high concentrations it may affect the nervous sytem.
The vapour and solutions irritate the eyes.
The solutions may irritate the skin.
Assumed to be poisonous if taken by mouth.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases or where splashing has occurred, obtain medical attention.
Skin contact: drench with water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink; obtain medical attention.

TRITOLYL PHOSPHATE (TRICRESYL PHOSPHATE). Pale brown, almost colourless, liquid; immiscible with water.

HARMFUL BY SKIN ABSORPTION
HARMFUL IF TAKEN INTERNALLY

Avoid contact with skin and eyes.

Acute Effects

When absorbed through the skin or ingested tritolyl phosphate may cause serious damage to the nervous and digestive systems. Poisoning may show itself in degrees of muscular pain and paralysis.

First Aid

Affected eyes: irrigate thoroughly with water and obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

URANIUM COMPOUNDS. The commonest uranium compounds encountered in the laboratory are the acetate, nitrate and double zinc and magnesium acetates, all of which are yellow crystalline salts soluble in water. Uranium hexafluoride is a colourless or pale yellow crystalline solid which sublimes readily at about 56°C.

HARMFUL DUSTS OR VAPOUR

Avoid breathing dust or vapour.
M.A.C. (soluble compounds) 0·05 mg/m³.
M.A.C. (insoluble compounds) 0·25 mg/m³.

Acute Effects

The dust may irritate the lungs and cause retention of uranium in the body with subsequent damage to the kidneys.
The vapour of the hexachloride irritates the respiratory system and may injure the kidneys.
Assumed to cause internal damage if taken by mouth.

First Aid

Dust or vapour inhaled: remove from exposure, wash out nose and mouth with water; obtain medical attention.
Affected eyes: irrigate thoroughly with water.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

VANADIUM COMPOUNDS. Vanadium pentoxide is a red-brown to dark brown powder. The other compounds most commonly encountered are the sodium and ammonium vanadates, which are colourless, crystalline, and soluble in water.

HARMFUL DUST
HARMFUL IF TAKEN INTERNALLY

Avoid breathing dust.
M.A.C. (dust) 0·5 mg/m³.
M.A.C. (fume) 0·1 mg/m³.

Acute Effects

The dust or fume of vanadium pentoxide causes irritation of the respiratory system, chest construction, coughing, and the tongue assumes a blackish-green colour.
The dust or fume irritates the eyes and may cause conjunctivitis.
If taken by mouth vanadium compounds cause vomiting, excessive salivation and diarrhoea; large doses may damage the nervous system, causing drowsiness, convulsions and unconsciousness.

First Aid

Dust or fume inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.
Affected eyes: irrigate thoroughly with water; in severe cases, obtain medical attention.
If swallowed: wash out mouth thoroughly with water and, if vomiting has not occurred, give emetic (p. 29); obtain medical attention.

XYLENES (XYLOLS) Colourless liquids; immiscible with water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

Inhalation of the vapour may cause dizziness, headache, nausea and mental confusion.
The vapour and liquid irritate the eyes and mucous membranes.
Absorption through the skin and ingestion would cause poisoning.

Chronic Effects

If the xylene contains benzene as an impurity repeated breathing of vapour over long periods may cause blood disease.
Prolonged skin contact may cause dermatitis.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water; if splashing has occurred, obtain medical attention.
Skin contact: drench with water and wash with soap and water; remove and air contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

XYLENOLS. With the exception of 2,4-xylenol, which is often encountered as a yellow-brown liquid, the commoner xylenols are colourless crystalline solids, slightly soluble in water.

HARMFUL BY SKIN ABSORPTION
CORROSIVE—CAUSES BURNS

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

The vapour of heated cresols is irritant to the respiratory system.
Xylenols irritate or burn the eyes and skin severely.
Considerable absorption through the skin or ingestion may cause headache, dizziness, nausea, vomiting, stomach pain, exhaustion and coma.

Chronic Effects

Repeated inhalation or absorption of small amounts may result in damage to the liver or kidneys.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm.
Affected eyes: irrigate thoroughly with water and, in the case of direct contact, obtain medical attention.
Skin contact: wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.
If swallowed: wash out mouth thoroughly with water and give plenty of water to drink followed by two tablespoonfuls of magnesium sulphate (Epsom salts) in water; obtain medical attention.

XYLIDINES. Most of the common xylidines are red to dark-brown liquids (3,4-xylidine consists of pale brown crystals); insoluble in water.

HARMFUL VAPOUR
HARMFUL BY SKIN ABSORPTION

Avoid breathing vapour. Avoid contact with skin and eyes.

Acute Effects

Excessive breathing of the vapour or absorption through the skin may cause headache, drowsiness, cyanosis, mental confusion and, in severe cases, convulsions.

The xylidines are dangerous to the eyes and the above effects may also be experienced if they are taken by mouth.

Chronic Effects

Prolonged exposure to the vapour or slight skin exposures over a period may affect the nervous system and the blood, causing fatigue, loss of appetite, headache and dizziness.

First Aid

Vapour inhaled: remove from exposure, rest and keep warm; in severe cases, obtain medical attention.

Affected eyes: irrigate thoroughly with water and when direct contact with the liquid or solid has occurred, obtain medical attention.

Skin contact: drench with water and wash thoroughly with soap and water; remove and wash contaminated clothing before re-use.

If swallowed: wash out mouth thoroughly with water and give emetic (p. 29); obtain medical attention.

V. PRECAUTIONS AGAINST RADIATIONS

V. PRECAUTIONS AGAINST RADIATIONS

This Section deals with the safe handling of small quantities of materials with low radioactivity in university, college and other general laboratories, perhaps adapted for the purpose. It is not intended to cover the precautions necessary in laboratories that are required to handle high-activity materials, for expert advice should then be obtained both on the design of special laboratories, on apparatus and instrumentation, and on the procedures to be followed.

The precautions that have to be taken will depend on several factors —the total quantity of radioactivity, the type of radiation emitted and whether the material being handled is a sealed or unsealed source of radiation. With unsealed sources there is a possibility that radioactive material may escape, with consequent local contamination, and this obviously calls for additional precautions as compared with sealed sources. The radioactive hazard increases with the quantity of radioactive material handled; therefore, wherever possible it is better not to store or use more material than is needed for the work proposed, unless special storage facilities are available.

With very small quantities of material, the precautions need not be very different from those adopted in normal good laboratory practice, the aim being to keep the laboratory surfaces clean and the air free from toxic agents. In particular, the risk of fire should be minimized by good housekeeping, such as the early disposal of inflammable packing material. The different types of radiation, the units of measurement and the effects of radiation will first be considered; the general principles underlying health and safety requirements will then be outlined, so as to see how these principles can be applied in the design and operation of laboratories and how the problems of decontamination and waste disposal can be met. Finally, a short account of ultra-violet and infra-red radiations will be given; these are not normally included in accounts of laboratory hazards, although it is important that precautions should be followed in making use of them.

TYPES OF RADIATION

The three types of ionizing radiation normally met in laboratory work are alpha, beta and gamma radiation. Although some materials emit only one type of radiation, it is more usual for a material to emit a mixture of radiations. The parent element often disintegrates into daughter elements, and the total radiation emitted arises from all members of the series. A well-known example of this is the radium series, in equilibrium with the parent element radium, which gives rise to alpha, beta and gamma radiation.

The penetrating power of all types of radiation is a function of the energy of the particle, which is usually expressed in terms of the electron volt (eV), that is, the energy which an electron possesses when it has experienced a fall of potential of one volt (1 keV = 10^3 eV, 1 MeV = 10^6 eV).

Alpha Radiation. Alpha particles are helium nuclei travelling at speeds equivalent to several MeV, and since they are intensely ionizing the energy is rapidly lost and the penetrating power is very small. A sheet of paper, for example, is sufficient to stop an alpha particle. A well-known example of an alpha emitter is polonium (^{210}Po), which emits particles with an energy of 5·3 MeV.

Beta and Gamma Radiation. The majority of materials met in the laboratory emit beta and gamma radiation. Beta radiation consists of electrons the energy of which varies over a wide range. A typical example of a beta-emitter is radioactive phosphorus (^{32}P), the beta particles ejected having velocities ranging from zero to a value corresponding to 1·7 MeV.

Gamma radiation consists of electromagnetic radiation, similar to X-rays, light and heat radiation but with a much shorter wavelength (10^{-4} mμ or 10^{-3} Å) and very penetrating. A typical gamma emitter is radioactive cobalt (^{60}Co), which emits gamma radiation at energy levels of 1·16 and 1·32 MeV respectively.

Neutron Radiation. Neutrons, together with protons, are the basic particles from which the nuclei of elements are made. The mass of each is approximately the same as that of the hydrogen atom, but whereas the proton has a positive electric charge the neutron is uncharged. A few materials, such as plutonium, produce neutrons spontaneously at a low rate, but the usual laboratory source is a mixture containing an alpha-emitter (such as radium or polonium) and beryllium. Slow neutrons are used in transmuting elements for use in activation analysis.

Positrons. A relatively small number of radioactive materials, as, for example, ^{11}C or ^{22}Na, emit positrons of the same mass as electrons, but having positive instead of negative charges. The penetrating power of positrons is similar to that of electrons, but they are unstable particles and rapidly combine with electrons to yield radiation similar to gamma radiation and having an energy of 0·5 MeV.

PENETRATING POWER OF VARIOUS RADIATIONS

The penetrating power of alpha radiation is small, and the skin itself offers fairly good protection. The main purpose of wearing gloves when handling alpha-emitters is to prevent the contamination not only of the hands, but also of other parts of the laboratory by the hands. If, by breathing contaminated material, alpha-emitters are

introduced into the body, a serious hazard arises from internal radiation, and, indeed, for many alpha-emitters the main danger arises from inhalation and subsequent lung damage.

The penetrating power of beta-particles is greater than that of alpha radiation and increases with increasing energy of the particles. Particles with an energy of 1 MeV may travel several metres in air but are absorbed by a few millimetres of material, even of low atomic weight. For many laboratory purposes a $\frac{1}{4}$-in. sheet of Perspex gives adequate protection. The eyes in particular should be protected by a face shield or by goggles.

Gamma radiation is more penetrating than beta radiation; for example, only 50 per cent of the gamma radiation from ^{60}Co is absorbed by a shield of lead 1 cm thick. The penetration increases with the energy of the gamma radiation and decreases with the density and atomic number of the material of the shield. Tables such as those published in the *Code of Practice for The Protection of Persons Exposed to Ionizing Radiations* or in the *British Journal of Radiology*, Supplement No. 6, should be consulted to determine the transmission from which the appropriate amount of shielding may be calculated. If a transparent shield is required, lead glass or one of the high-density glasses may be used.

QUANTITIES OF RADIOACTIVITY AND UNITS OF DOSE

Quantities of radioactivity are normally stated in terms of curies. One curie is the quantity of any radioactive nuclide* in which the number of disintegrations per second is $3{\cdot}7 \times 10^{10}$, *viz.* the radioactivity of 1 g of radium in equilibrium with its daughter product, radon. For many purposes this unit is too large, and the millicurie (mc, $3{\cdot}7 \times 10^7$ dis/sec) and microcurie (μc, $3{\cdot}7 \times 10^4$ dis/sec) are then used. The specific activity of a radioactive material is normally expressed in c/g.

The rate of disintegration varies over a wide range and is usually expressed in terms of its half-life, that is, the time taken for the amount of radioactivity emitted from an isotope to decrease to half its initial value.

The first unit of radiation dose to receive international recognition was the *röntgen*, which may be defined as that quantity of X- or gamma-radiation which produces in 1 cc of air at 0°C and 760 mm ion-pairs carrying one e.s.u. of electricity of either sign. For many purposes the röntgen is a large unit, and use is then made of the smaller units, milliröntgen (mr) and microröntgen (μr). The unit of dose *absorbed* is the rad, and is equivalent to a dose giving absorbed

* The term 'nuclide' denotes any single element consisting of atoms of the same mass number. Strictly, the term 'isotopes' refers to the constituents of a mixture of nuclides of identical chemical properties but of different atomic weights.

energy amounting to 100 erg/g of the absorbing substance. For some purposes the rad and the röntgen (equivalent to 83 erg/g of air) may be treated as equal.

TABLE I

EXAMPLES OF RADIOACTIVE ISOTOPES AND THEIR PHYSICAL PROPERTIES

Isotope	Half-life	Gamma-ray energy (MeV)	Beta-ray energy (maximum MeV)
^{22}Na	2·6 years	1·28	0·54 (mainly)
^{24}Na	15·0 hours	1·38, 2·76	1·39
^{42}K	12·4 hours	1·51	3·68, 2·04
^{51}Cr	27 days	0·32	0·005
^{59}Fe	47 days	1·1, 1·3	0·46, 0·27
^{58}Co	70 days	0·81, 1·62	0·47
^{60}Co	5·3 years	1·17, 1·33	0·31
^{82}Br	36 hours	0·54–1·45	0·47
^{131}I	8·0 days	0·08–0·72 (mainly 0·36)	0·25–0·62 (mainly 0·61)
^{132}I	2·3 days	0·73–2·13	0·52–2·2
^{198}Au	2·7 days	0·41–0·68 (mainly 0·41)	0·96 (mainly)
^{3}H	12·3 years	—	0·018
^{14}C	5,600 years	—	0·155
^{32}P	14·3 days	—	1·70
^{35}S	87·1 days	—	0·167
$^{90}Sr + {}^{90}Y$	28 years (Sr)	—	0·54 + 2·24

The biological effect of radiation is invariably harmful; it depends not only on the absorbed dose, but also on the nature of the biological material, the type of radiation and the time over which the radiation dose is spread. In an attempt to cover the various types of radiation, a further unit, the *rem* (röntgen-equivalent-man) has been introduced. One rem is the quantity of ionizing radiation such that the energy imparted to 1 g of living matter has the same biological effect as one rad of 200-keV X-radiation; thus one rad of alpha radiation is equivalent to 10 rad of 200-keV X-radiation. This factor 10 is known as the *relative biological effectiveness* (R.B.E.). Since the mechanisms of ionization for beta radiation, gamma radiation and X-radiation are thought to be very similar, the R.B.E. for these radiations is approximately unity.

PHYSICAL EFFECTS OF RADIATION

Most biological effects arise from a primary ionization effect, that is, an electron is ejected from the molecule to form an ion-pair or, if sufficient energy is not available to do this, the electron is displaced, leaving the molecule in an excited state. Reaction with the nucleus, causing the material itself to become radioactive, only occurs with radiation of energy above 20 MeV.

Substantial doses of radiation are required to produce detectable changes in inanimate matter. For example, changes can be

demonstrated in materials like plastics when the dose is of the order of 10^7 rad; for metals the corresponding dose is 10^{12} rad; but these doses are far higher than are normally encountered in a laboratory.

EFFECT OF RADIATION ON LIVING MATTER

The fundamental effect of radiation on any living organism is damage to cells, especially to those which are actively dividing to produce new daughter cells, such as the germinal tissue of the reproductive organs and the bone marrow, which is responsible for the manufacture of the red and white cells of the blood. The tissues of the fœtus are also especially vulnerable. Cells that perform special functions are said to be differentiated, and the sensitivity of these cells to radiation varies widely. Small doses of radiation often cause delay in cell division and damage to the chromosomes; larger doses will cause the cells to degenerate. The amount of primary damage increases with the dose of radiation absorbed. The capacity of an organism to repair radiation damage is, as one would expect, dependent on the dose rate. Severe damage to some cells may be irreparable, as, for example, the germinal epithelium, so that if the animal survives, its functioning may be impaired.

Small organisms such as bacteria are much more resistant to the effects of radiation than animals. Bacteria will often survive a dose of radiation which would be fatal to an animal.

The effect of radiation depends on many factors, including the total dose and the time over which it is given, and is smaller if the radiation dose rate is decreased. It is still not known whether there is a threshold dose of radiation below which there is no apparent effect on the organism, or whether all radiation is deleterious even at very low dose rates.

The total effect of radiation on an individual depends on the part of the body and the volume of tissue irradiated. The exposure of the upper abdomen, for example, may produce immediate symptoms, whereas a similar dose given to a portion of a limb will produce no apparent effect. Young people are more susceptible to irradiation than adults. The unborn baby is especially vulnerable.

As yet, there is little direct information about the genetic effects of ionizing radiations on man. On the basis of experience with plants and animals, it is likely that even small doses of radiation will cause irreparable damage to chromosomes and genes, giving rise to genetic damage which may show itself in the descendants of the exposed person.

MAXIMUM PERMISSIBLE LEVELS OF RADIATION DOSE

EXTERNAL RADIATION

There is a natural background of radiation that arises from naturally radioactive substances in the body itself, from the materials used in the construction of buildings, from the earth and from cosmic rays

originating outside the earth. The total radiation received from all these causes varies and is of the order of 0·1 rem/year. Civilized man is also subjected to medical procedures, such as X-ray diagnosis, in which a further small quantity of radiation is received. The testing of nuclear weapons adds a further small quantity of radiation from the fission products released, and this contribution extends over a long period of time as the fission products descend from the stratosphere.

The most recent pronouncement on maximum permissible levels is that issued by the International Commission on Radiological Protection in 1959. This document should be consulted, but a brief summary of the levels recommended for radiation workers is as follows:

(1) The total dose during any 13 consecutive weeks shall not exceed 3 rem.

(2) The cumulative whole body dose (D) at any age N years shall not exceed that given by the formula $D = 5\ (N - 18)$ rem.

(3) The dose received by the skin and the thyroid gland shall not exceed 8 rem in any consecutive 13 weeks and shall not exceed 30 rem in any one year.

(4) For organs other than skin and thyroid the dose in any 13 consecutive weeks shall not exceed 4 rem and in any one year shall not exceed 15 rem.

The document also gives guidance on the protection of the public. The annual dose received by members of the public shall not exceed 0·5 rem per year. A special group of adults in the vicinity of a controlled area may receive an annual dose not exceeding 1·5 rem. If the total dose is likely to exceed these limits, expert advice should be sought from the Ministry of Health and Medical Research Council Radiological Protection Service at Sutton, Surrey.

INTERNAL RADIATION

The report[2] of Committee II on Permissible Dose for Internal Radiation (1959) gives recommendations for maximum permissible levels of radionuclides in air and water. The levels limit the estimated dose to various critical organs of the body, *e.g.* 0·1 rem/wk to the gonads and total body, 0·6 rem/wk to the skin and 0·3 rem/wk for other soft tissues. For certain nuclides which accumulate in bone, *e.g.* ^{90}Sr, ^{239}Pu, the levels are those estimated not to exceed the damage produced by a body burden of 0·1 μc of ^{226}Ra.

The danger from internal radiation arises from the breathing of contaminated air or the ingestion of radioactive materials. Both of these may arise from radioactive gases in the laboratory, including $^{14}CO_2$ in biological experiments as well as from contaminated laboratory surfaces. The danger arising from any particular element depends on the total amount of radioactive isotope, the type of radiation it

emits, its effective half-life in the body (which will be determined by the rate of elimination via kidneys, lungs, skin or gut) and the manner in which it becomes distributed through the body.

The dangers may be illustrated by considering two materials such as radioactive strontium ^{90}Sr and radioactive sodium ^{24}Na. Sodium concentrates only to a limited extent in the bones, so that since ^{24}Na has a short physical half-life of 15 hours it is much less hazardous than ^{80}Sr (half-life 28 yr) which concentrates in bone and has a low metabolic turnover (effective half-life greater than 5 yr).

LABORATORY DESIGN AND OPERATION

GENERAL PRINCIPLES

The operational maximum permissible levels outlined on the previous page ensure safe working conditions for personnel. When designing a new laboratory or modifying shielding, the calculations should be based on an exposure in the working areas of 0·1 rem/wk (2·5 mrem/hr). The operational control figure is 3 rem/13 wk (7·5 mrem/hr), but it should be noted that a dose rate of 2·5 rem/hr regularly received for 40 hours per week gives a total dose of approximately 5 rem over the whole year.

Before considering in detail the classification of laboratories it should be pointed out that the problem of internal radiation can be overcome to a large extent by following the rules of good housekeeping. In most laboratories, if care is taken to avoid spills and to deal quickly and adequately with any that do occur, and if a regular and frequent cleaning programme is followed, surface contamination will be kept to a very low level and this in turn will prevent any real danger arising from air contamination.

Except for work with the smallest quantities of isotopes, laboratories should, if possible, be specially allocated for radioactive work and should not be used for other purposes. In a large laboratory, a section may be set apart for radioactive work, but it should not then be used for ordinary chemical work. This is particularly important if the radioactive material is unsealed. If space is available it is useful to have separate laboratories to deal with different levels of activity or specific materials.

The head of the laboratory should issue safety rules and ensure that they are obeyed; in particular, any procedure likely to increase the intake of radioactive material into the body should be prohibited. For example, there should be a strict ban on eating and drinking in the neighbourhood of radioactive materials.

CLASSIFICATION OF LABORATORIES

It is convenient to grade laboratories according to the isotopes being handled and the quantities involved (*see* Table II). Thus a

Grade A laboratory is usually specially designed, but a Grade C laboratory may be a normal laboratory with slight modifications for handling small quantities of the less hazardous materials.

TABLE II

GRADE OF LABORATORY REQUIRED FOR VARIOUS QUANTITIES OF ISOTOPES OF VARIOUS RADIO-TOXICITIES

Relative radio-toxicity of isotope	Classification	Grade of laboratory required for unsealed isotopes at rough levels of activity specified below		
		C	B	A
Very high ..	1	< 10 μc	100 μc – 1 mc	> 10 mc
High	2	<100 μc	1 mc– 10 mc	>100 mc
Moderate ..	3	< 1 mc	10 mc–100 mc	> 1 c
Slight	4	< 10 mc	100 mc– 1 c	> 10 c

Procedure	Modifying factor*
Storage (stock solutions)	×100
Very simple wet operations	×10
Normal chemical operations	×1
Complex wet operations with risk of spills Simple dry operations	×0·1
Dry and dusty operations	×0·01

* The amounts of radioactive substances shown in Table II may be multiplied by these factors to modify the permitted dose according to the procedures used.

Table III shows the relative toxicity of some of the commonly used radioactive isotopes.

TABLE III

CLASSIFICATION OF ISOTOPES ACCORDING TO RELATIVE RADIO-TOXICITY PER UNIT AMOUNT

(The isotopes in each class are listed in order of increasing atomic number)

Class 1. Very high toxicity

Sr–90 + Y–90, *Pb–210 + Bi–210 (Ra D + E), Po–210, At–211, Ra–226 + 55 per cent *daughter products, Ac–227, *U–233, Pu–239, *Am–241, Cm–242.

Class 2. High toxicity

Ca–45, *Fe–59, Sr–89, Y–91, Ru–106 + *Rh–106, *I–131, *Ba–140 + La–140, Ce–144 + *Pr–144, Sm–151, *Eu–154, *Tm–170, *Th–234 + *Pa–234, *natural thorium, *natural uranium.

Class 3. Moderate toxicity

*Na–22, *Na–24, P–32, S–35, Cl–36, *K–42, *Sc–46, Sc–47, *Sc–48, *V–48, *Mn–52, *Mn–54, *Mn–56, Fe–55, *Co–58, *Co–60, Ni–59, *Cu–64, *Zn–65, *Ga–72, *As–74, *As–76, *Br–82, *Rb–86, *Zr–95 + *Nb–95, *Nb–95, *Mo–99, Tc–96, *Rh–105, Pd–103 + Rh–103, *Ag–105, Ag–111, Cd–109 + *Ag–109, *Sn–113, *Te–127, *Te–129, *I–132, Cs–137 + *Ba–137, *La–140, Pr–143, Pm–147, *Ho–166, *Lu–177, *Ta–182, *W–181, *Re–183, *Ir–190, *Ir–192, *Pt–191, *Pt–193, *Au–196, *Au–198, *Au–199, *Tl–200, Tl–202, Tl–204, *Pb–203.

Class 4. Slight toxicity

H–3, *Be–7, C–14, F–18, *Cr–51, Ge–71, *Tl–201.

* γ-emitters. It is not yet agreed whether natural uranium should be included under Class 2 or Class 3.

DESIGNATION OF AREAS

The siting of laboratories should be considered from the point of view of possible spread of contamination to 'clean' areas where non-active work is proceeding. The general direction of movement of ventilating air should always be towards the area of highest radioactivity. Equipment which has been used in an active laboratory should not subsequently be used in a 'clean' laboratory unless steps are taken to ensure its decontamination. Areas in radioactive laboratories are sometimes graded as white, green, amber or red; white areas being free of all radioactivity, and red areas sufficiently active to require special clothing and restricted entry. For laboratories other than Grade A, the areas would normally be white or green, with the occasional need to designate an area amber.

GRADE C LABORATORY

Few modifications are required in any modern conventional laboratory to make it suitable for small-scale radioactive work. Consideration should be given first to the layout of the laboratory to ensure that possible spills and contamination are restricted to given areas and kept away from counting areas and offices. It will probably be necessary to provide extra washing facilities and additional waste containers for contaminated material.

The areas designated for radioactive work should already be provided with smooth, inert, non-absorbent surfaces, free from cracks and inaccessible corners; otherwise shallow trays and polythene sheet should be provided to protect bench tops and so on. So that dust will not collect, there should be no horizontal surfaces above eye level. The aim should be to receive a possible spill either on a surface which can be readily cleaned or on a surface which can be easily disposed of later. Linoleum is a satisfactory floor covering, but it should be examined to ensure that it is well-fitting. Sometimes it would be useful to cover a part of the floor area, such as a passageway, with PVC sheet, which can be disposed of later.

Laboratories should have at least one fume cupboard with induced draught. The fume cupboard would be used for any process that might involve the production of vapour or particulate matter carrying radioactivity with it, and would also be useful for temporary storage of unsealed radioactive materials. Interlocking lead bricks may be built into a temporary wall when required. In this type of laboratory it would not normally be necessary to fit a filter in the exhaust duct of the fume cupboard.

GRADE B LABORATORY

Here some extra care is required, both in the design and in the operational procedure, to ensure effective control of contamination.

For certain operations a glove box, that is, an enclosure in which material may be manipulated in isolation from the operator's environment, may be necessary. It is primarily used to avoid dangers arising from the inhalation of dust, especially with alpha-emitting radioactive materials. The operator works through glove ports, which are normally so constructed that new gloves can be fitted without breaking the seal.

GRADE A LABORATORY

If a large quantity of highly toxic radioactive material is to be handled, specialized advice should be sought; a modified laboratory is not good enough.

PREVENTION OF CONTAMINATION

Regular monitoring should be instituted to detect accidental or unrecognized contamination on working surfaces, and there should be good ventilation of those spaces where there is a significant hazard of contamination by radiation. At specified points there should be an adequate linear movement of air away from clean areas to prevent back-diffusion. Some control may have to be maintained over the opening of windows and doors, as this may upset the planned movement of air. It is customary to indicate ventilation requirements in terms of changes per hour, but this in itself may not be adequate, and attention should be paid to the rate and direction of flow of air at all points in the laboratory where a hazard may arise; if necessary, experimental tests should be carried out to check the arrangements.

Strict control should be maintained over the movement of contaminated materials; the design and operation of the laboratory should be such as to encourage minimum movement, particularly of unsealed sources. Where necessary, contaminated articles should be wrapped in PVC or polythene sheet before being removed from a possibly contaminated area.

OPERATIONAL PROCEDURE

It is recommended that workers about to embark on radioactive work for the first time should visit other laboratories and study the methods they see employed. Before beginning their own work, they should first do a 'dummy run', that is, go through all the required procedures with non-radioactive material. Experience may thus be gained and modifications introduced without incurring any risk. It is also wise to gain experience with the less hazardous materials, such as radioactive phosphorus, before handling such materials as polonium or strontium.

PROTECTION OF PERSONNEL

The best way to ensure adequate protection against gamma and hard beta radiation is to have permanent shielding, standing on its own base and suitably placed to allow the work to be done quickly

and efficiently without any additional personal protection. Thin rubber gloves give personal protection against alpha radiation, but offer no real protection against other radiations. Circumstances in which special protective clothing or respirators are required are beyond the scope of this book.

PERSONNEL MONITORS AND DOSE RECORDS

It is recommended that, although the dangers arising from external radiation in Grade B and C laboratories are small, the recording of one's personal dose should be carried out as a matter of routine. This is conveniently done by wearing a film badge, which, on subsequent development, indicates the total dose of external radiation received. If the film badge is provided with the appropriate filters, such as lead, tin and cadmium, differentiation can be made between the external radiation exposure due to beta, X, gamma and neutron radiation. (The Radiological Protection Service based at Sutton provides a very good film badge service.)

It is important that the employer and the person concerned should know the dose of radiation to which the worker has been exposed and that a record of this radiation should be made routinely week by week, or month by month, according to the radiation level. The doses should be entered on individual cards, and it is convenient to total the doses each quarter, each year and each decade. In general, the totals will be well within the recommended dose levels given earlier, but in the rare cases where the recommended levels are exceeded, appropriate steps should be taken, including possibly a change of job. When a worker moves from one employer to another, the new employer should be made aware of the worker's radiation history.

For special purposes the film badge may be supplemented by a personal radiation monitor, such as a Quartz Fibre Electrometer. This is very useful to check the dose at the time it is received by a worker in areas where the radiation dose rate is higher than the maximum permissible level and where there is a limitation on the working time.

LABORATORY INSTRUMENTATION

Instruments capable of measuring external radiation and contamination levels are essential in all laboratories where a significant amount of radioactive material is handled. In laboratories of very low activity their main purpose will be to demonstrate good working conditions. In Grade A and possibly in Grade B laboratories, they could fulfil the additional function of indicating maximum permissible working times. The instruments may be divided into three groups:

(*a*) radiation survey instruments;

(*b*) contamination measuring instruments;

(*c*) dust samplers.

Radiation Survey Instruments. The Harwell Type 1368 instrument makes use of a Geiger counter as detector, is portable, uses transistorized circuits, is battery-operated and has five sensitivity ranges, covering radiation levels over the range 0·05 mr/hr up to 25 mr/hr. It has a separate probe for the measurement of beta activity and headphones to give an aural indication of count rate. A very useful survey meter of less sensitivity is Harwell Type 1349. It is portable, battery-operated and uses an ionization chamber as the detection unit. The range covered by this instrument is from 15 mr/hr up to 1,500 mr/hr. These two instruments will cover most requirements and they can, on occasion, be supplemented by making use of the ordinary laboratory counting equipment.

These instruments may be supplemented by others designed for special problems. A complete list of such apparatus may be obtained from the A.E.R.E., Harwell, or from the Scientific Instrument Manufacturers' Association, 20 Queen Anne Street, London, W.1.

MEDICAL EXAMINATION

Before first working with radioactive material, all persons should have a medical examination, including a full blood count, and this should be followed by routine medical examinations. (If the dose to which the staff is exposed during the year is less than 0·5 rem, these precautions are unnecessary.)

The main purpose of the initial medical examination is to prevent anyone undertaking radiation work if his initial state and history do not fit him for it. It is essential to be able to produce a record of the results of this initial medical examination if a laboratory worker later shows deterioration in health, and it has to be decided whether or not this has been caused by radiation work. Pregnant women should not work in laboratories where radioactive substances are in use.

Even a small quantity of radioactive material in a cut can be dangerous. For example, when a cut has been produced by contaminated glassware, the minimum treatment is to wash the cut immediately and very carefully with copious amounts of water and then refer the case as soon as possible to the nearest large hospital, which will have a medical department familiar with the handling of radioactive isotopes. It is important that contamination should be removed from the wound before it has time to invade the body generally.

DETAILED LABORATORY ORGANIZATION

LAYOUT AND STORAGE

Here we are concerned with the modifications necessary when a good chemistry laboratory is to be made suitable for work with microcurie quantities of radioactive material, and where the radioactive material itself is of low or medium toxicity. To apply the general

principles of safe handling of radioactive materials already outlined, the general arrangement of the laboratory should be studied from the point of view of allocating certain operations to specified areas. For example, a suitable area should be selected for radioactive counting, and every effort should be made to keep it scrupulously clean and free from contamination (*see* p. 164). Similarly, areas chosen for the actual dispensing of radioactive materials should be placed at a distance from the counting area and from other non-active areas. In order to reduce the carriage of radioactive materials, this area should be conveniently close to the radioactive store. A plan should be drawn clearly indicating the areas allotted for specific purposes and the appropriate rooms or areas should be clearly labelled. If the laboratory workers do not rigidly adhere to the system, the counting area will not be kept permanently free from contamination, the background will increase and the accuracy of low-level counting will be impaired.

Provision should be made for the storage of radioactive material, both when it is first received and also when it is not in actual use. All radioactive containers should be adequately protected against mechanical damage and possible theft. A careful record should be kept of all materials in the store. In Grade B laboratories the store should be provided with adequate shielding to reduce external radiation to very low values, and this may be supplemented by having certain of the radioactive sources in their own lead pots. The store should include a lead-lined safe to house radioactive sources, and the custody of the key of the safe should be the responsibility of the head of the laboratory or his deputy. If possible, the radiation level in the neighbourhood of the store should be less than 5 rem/year. If the dose rates exceed this value, then the store should be in such a position that nobody can spend any significant fraction of his time near to the store. There should be a danger notice indicating clearly that this is a radiation area. In some laboratories a store will need to be established in the laboratory itself, perhaps at the back of a fume cupboard. If this is done it should be suitably marked out, labelled and shielded with a temporary lead brick wall. The external dose rates should be kept very low indeed.

In Grade C laboratories, the problem of waste disposal of low radioactive material is small, but it would be useful to have foot-operated disposal cans of a distinctive colour in which contaminated waste can be kept separate from ordinary waste. At regular intervals this material should be monitored and, in the absence of any significant radiation, disposed of in the ordinary way. The methods of waste disposal if a significant amount of activity is present are discussed below.

PERSONAL PROTECTION

Workers should wear the normal laboratory overall. If gloves are worn, they must always be checked to be free from holes and should

be washed before removal and precautions taken to avoid contamination of the skin. A clean pair of gloves should be worn for each special operation, and great care should be observed that the gloves are 'peeled' off. The hands should be washed in a conveniently placed wash-basin and monitored after all radioactive work. If, after repeated washing, the hands remain contaminated the worker must visit the nearest large hospital familiar with the handling of radioactive isotopes, for expert decontamination. At the end of the day's work or when a particular job has been completed, the laboratory benches should be returned to a normal condition and tests made to ensure that there has been no spread of contamination.

DECONTAMINATION AND WASTE DISPOSAL

The best way to deal with the problem of decontamination is to avoid contamination by careful work, but any spills *must* be cleaned up before evaporation occurs. Temporary surface coverings of paper, PVC or polythene sheet can be disposed of when necessary. The greater portion of the spill may be absorbed on material such as cloth or blotting paper. The contaminated material should be placed in a suitable receptacle ready for subsequent disposal. Cleaning measures can then be undertaken for the remainder of the spill. Usually the best cleaning agent is water itself, or water and a detergent.

If monitoring shows that the simple cleaning methods have failed, then more drastic methods will have to be used, although the final steps should still be cleaning with water. Complexing agents, such as sodium salts of E.D.T.A. and polyphosphates, may help. These agents can be bought as creams in which they are compounded with sodium alginate or incorporated with soap. Glass surfaces may be cleaned by normal methods, including those making use of strong acids. With other surfaces, strong acids or alkalis should only be used when other methods have failed, for they are likely to damage the surfaces and make any subsequent decontamination difficult.

The skin may usually be freed from contamination by washing with warm soapy water, and then with clean water. A soft brush may be used, but care should be taken not to damage the skin. If simple methods are not effective, the laboratory worker should receive more elaborate cleaning treatment under medical care. To deal with stubborn skin contamination a solution of potassium permanganate, followed by a weak solution of sodium bisulphite, may be used.

WASTE DISPOSAL

The head of the laboratory, or his deputy, knowing the total amount of radioactive material that is likely to be handled in a 12-month period, should assess the amount of solid and liquid waste which may

have to be disposed of during the year. An approach should then be made to the appropriate authorities, national and local, to seek an authorization, which would state the monthly disposal averaged over any three-month period, taking into account the nature of the waste material. Grade C laboratories provide no problem, and it is unlikely that for Grade B laboratories this authorization would be restrictive.

The main principle of waste disposal is to ensure that no harm can result either to the people doing the job, to the public generally or to the men working with the sewage. Waste disposal resolves itself into dealing with solid and liquid waste, both of which may arise either from the experiment itself or from cleaning processes, including dealing with a spill. Waste pipes carrying radioactive materials (*see* below) should pass as directly as possible to the drains and not through other laboratories. (An active drain passing near the counting area may have a disturbing effect on the background count.)

Liquid Waste. The maximum permissible concentrations of radioactive isotopes in drinking water have been published as recommendations of the International Commission on Radiological Protection,[2] and it is important that these figures should not be exceeded. A few figures are given in this paragraph as a guide. Although the authorization must be agreed with the appropriate authority, the average concentration in the sewer from the laboratory should not exceed 10^{-4} μc/ml, nor the peak concentration exceed 1 μc/ml. The total amount that can be disposed of per day is a function of the total quantity of water available for dilution; as a guide, if the population served by the sewage undertaking is 50,000 or more, the disposal of up to 5 mc/day is not likely to be harmful. It is advised that no single quantity of liquid waste should exceed 1 mc.

Solid Waste. This presents a more difficult problem, since safety cannot be achieved by dilution. There should be regular monitoring of the receptacles set aside for solid radioactive waste, and these receptacles should be emptied regularly. An acceptable surface dose rate for the waste container is 1 mr/hr, and a single load of waste material should not exceed 100 μc. If monitoring shows that these levels are exceeded, immediate steps should be taken to remove the material from the precincts of the laboratory and store it under controlled conditions until the activity has decreased.

If solid waste is burned, there is a danger to the man in charge of the incinerator and also a possibly dangerous discharge of gaseous effluent. Except for very bulky material of very low activity, it is preferable to bury solid waste in trenches lined with concrete and not to burn it. The advice of the Ministry of Housing and Local Government should be sought before making detailed plans for the disposal of solid waste.

RESPONSIBILITY FOR SAFETY

In any department using radio-isotopes the responsibility for the safety aspects rests upon the head of the laboratory but it may be delegated to a competent person, who may with advantage have received instruction either in another approved laboratory or at a recognized training course.

The competent person should be responsible for the issue of clear safety regulations and the posting of notices to control the day-to-day working of the laboratory from a safety point of view. He should also be able to advise on the design of new laboratories or the modification of existing laboratories, and to assist the laboratory personnel to do their work efficiently and, at the same time, safely.

He will also be responsible for the keeping of radiation-dose records. This would ensure that the dose of radiation does not exceed the recommended levels and would assist in ensuring that every individual worker receives as little radiation as possible.

In the case of accidental over-exposure, he will advise on the measures to be taken to bring the dose within permitted limits. In the case of an accidental spill, he will advise on the methods of cleaning up and, following the necessary monitoring, he will indicate when normal work can be resumed.

He will be responsible for the maintenance of instruments and their calibration from time to time.

He will also undertake liaison with national and local bodies to ensure that waste disposal is done safely and within authorized limits.

The Ministry of Labour has issued a second preliminary draft[11] of the Factories (Ionizing Radiations) Special Regulations governing work in factories in which ionizing radiations are involved. This draft covers sealed sources of radio-isotopes and X-ray machines and there will be issued later a further draft to cover unsealed sources.

The Regulations lay down the duties of the competent person and the appointed doctor and indicate the responsibility of the head of a laboratory, including the keeping of a health register.

The head of the laboratory has the final responsibility for health and safety but it is unlikely that he can combine his ordinary duties with those which he would delegate to the competent person. Both he and the competent person will seek advice from a well-qualified and experienced health physicist when the need arises. There are a number of courses[15] organized by universities and technical colleges for the training of health physicists and competent persons.

ULTRA-VIOLET AND INFRA-RED RADIATION

Ultra-violet light may give rise to superficial eye damage and to burning of the skin, not unlike that produced by over-exposure to the sun. A few seconds exposure of the eye to an unscreened arc

at a distance of several yards may cause an extremely painful condition generally known as 'eye flash'. The characteristic symptoms are a feeling as of sand in the eyes accompanied by intense pain, intolerance to light, watering of the eyes and possibly temporary loss of vision. In a laboratory where ultra-violet radiation is produced in a confined space, there is a possible danger to persons in the area from excessive concentration of ozone, which has an irritant action on the upper respiratory system. The American Medical Association has recommended that individuals should not be exposed to intensities of ultra-violet light greater than 0·5 $\mu W/cm^2$ (7-hour day), or 0·1 $\mu W/cm^2$ (24-hour day). A monitoring instrument suitable for the purpose of measurement has been described by Andrews (*Rev. sci. Instrum.*, 1945, **16**, 253).

Precautions. Protective cabinets or screens should be placed around the source of emission and a screen of ultra-violet-absorbing glass should be interposed between the worker and the source of radiation. It is easier to do this if the area of ultra-violet radiation is limited to the minimum necessary. Approved goggles should be worn and, where necessary, hands and forearms should be protected by cotton material or suitable barrier creams. To guard against the danger from ozone already mentioned, the room should be well ventilated.

INFRA-RED RADIATION

Since infra-red radiation is readily absorbed by surface tissues it does not inflict any deep injuries. In the case of the eyes, the heat absorbed by the lens of the eye from infra-red radiation is not readily dispersed, and a cataract may be produced. This condition is often known as 'chain-maker's eye', but it is also found in glass blowers and furnace attendants.

Precautions. All sources of intense infra-red radiation should be shielded as near to the source as practicable by heat-absorbing screens, to prevent the radiation entering the eyes of the workers. Approved goggles or eye shields should be worn, and since this may result in a loss of light entering the eye, the general illumination of the laboratory should be increased appropriately.

GENERAL PRECAUTIONS

Workers should be made aware of the possible dangers either by individual instruction or by official notices. In all cases where there is evidence of clinical damage, the worker concerned should be referred to the nearest large hospital without delay.

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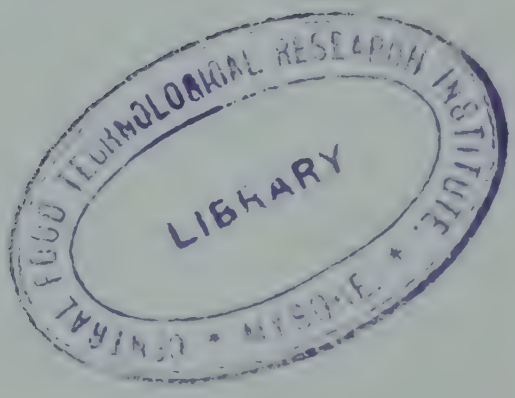
Glossary

Accommodation	Adjustment of the eye for various distances.
Acne	A disease of the sweat glands.
Agranulocytosis	An acute disease characterized by marked reduction in white cells of the blood.
Anaemia	Deficiency or imbalance of constituents of the blood; loss of red cells or iron-containing pigment.
Anaphylactic Shock	A severe, sometimes lethal, reaction following repeated entry of a foreign substance into the body.
Antibody	A specific substance which is produced to neutralize the effect of entry of a foreign substance into the body.
Antigen	Any substance which, when introduced into the blood or tissues, incites the formation of an antibody.
Ataxia	Failure of muscular co-ordination; irregularity of muscular action.
Bronchiectasis	A chronic widening of the bronchial tubes with formation of cavities containing pus.
Bronchitis	Inflammation of the bronchial tubes.
Bronchopneumonia	Inflammation of the lungs.
Carcinogenic	Producing cancer.
Coma	State of complete loss of consciousness from which the patient cannot be aroused even by the most powerful stimulation.
Conjunctivitis	Inflammation of the whites of the eyes.
Cyanosis	Grey-blue discoloration of the skin.
Detoxicated	Having the toxic or poisonous quality removed.
Emetic	A medicine that causes vomiting.
Emphysema	The presence of air in the substance of the lungs instead of in the proper air spaces.
Exfoliative	Inflammatory changes in the skin, including eruptions.
Furuncle	A boil.
Gastro-enteritis	Inflammation of the stomach and intestines.
Hepatitis	Inflammation of the liver.
Impetigo	An inflammatory skin disease.
Ingestion	The act of taking food, medicines, etc., into the body, as into the stomach.
Iritis	Inflammation of the iris.
Jaundice	Yellow discoloration of the skin and eyes.
Keratitis	Inflammation of the front of the eyeball.
Leukaemia	A fatal disease with excessive formation of white blood cells.
M.A.C.	Abbreviation for 'maximum allowable concentration'.
Metabolized	Undergone chemical change in the body.
Mucous Membranes	The moist lining or coating of the various passages of the body, as of the mouth, nose, alimentary canal, etc.
Narcotic	Producing drowsiness or unconsciousness.
Nephritis	Inflammation of the kidney.
Neuritis	Inflammation of a nerve.
Nystagmus	An involuntary rapid movement of the eyeball.
Oedema	The presence of abnormally large amounts of fluid in the tissues of the body.
Parkinsonism	A chronic condition marked by tremor and rigidity of the body.
Polyneuritis	Inflammation of many nerves at once.
Prophylactic	A remedy which tends to ward off disease.
Respiratory Tract	Nose, throat, windpipe and lungs.
Salivation	Excessive production of saliva.
Sensitization	Susceptibility to re-exposure to certain substances which have once caused harmful effects.

Septum	A dividing wall or partition.
Shock and Surgical Shock	Weakness or collapse; extreme prostration with feeble pulse and respiration and cold extremities, due to failure of the circulation.
Spastic	With stiff muscles.
Stupor	Extreme drowsiness but capable of being aroused.
Tinnitus	A noise in the ears.
Urticaria	Nettle rash.



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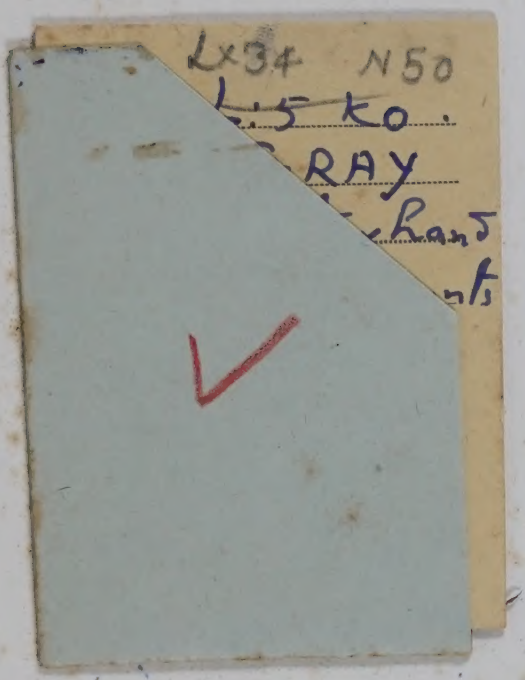
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